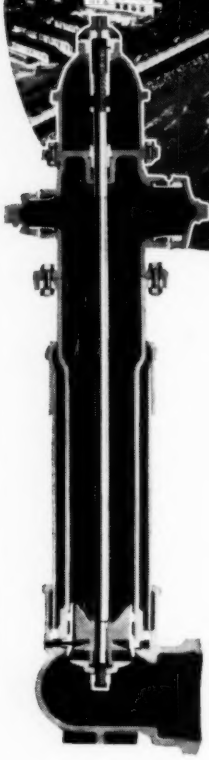
FEBRUARY 1949

Journal

VOL. 41 • NO. 2

AMERICAN WATER WORKS ASSOCIATION

Underwater worker on the Saginaw-Midland intake



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THE MATHEWS FIREMEN SAY

That's because this great island-city, "Gateway to the Southwest," is protected by Mathews Hydrants, and wherever you find these hydrants you find safety-plus.

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Send for complete description about these proved guardians of life and property. Your community, the most important in the world to you, deserves the best in fire protection.

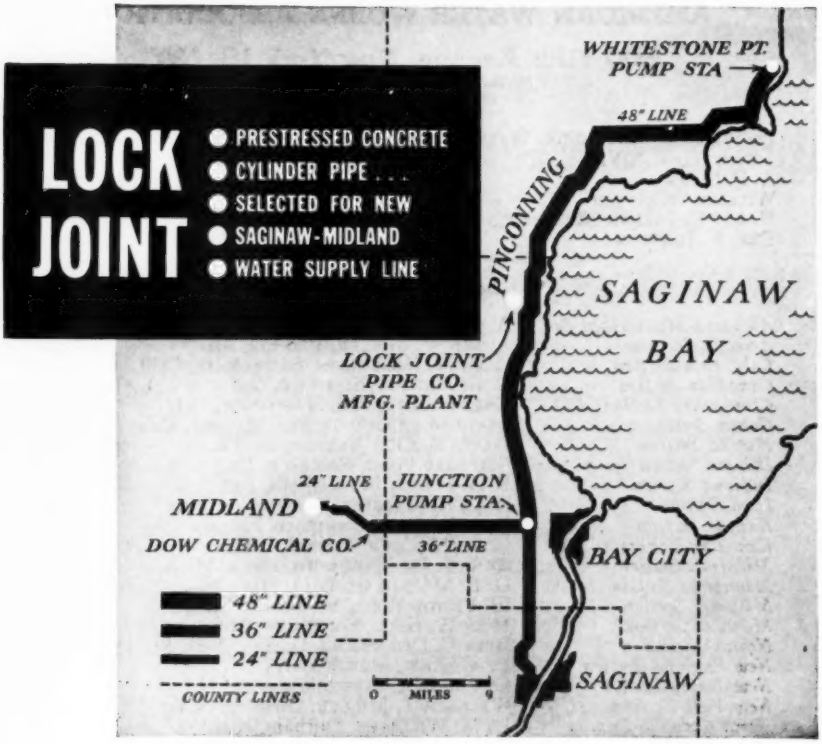
OTHER MATHEWS FEATURES: Head can be rotated 360° Replaceable head—nozzle outlets easily changed • Nozzle levels raised or lowered—no excavating • True compression-type main valve • Only one part to lubricate—operating thread • A modern barrel makes even the oldest Mathews new

MATHEWS HYDRANTS

***Made by* R. D. WOOD COMPANY**

Public Ledger Building, Independence Square, Philadelphia 5, Pa.

Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves



ONCE AGAIN, Lock Joint Prestressed Concrete Cylinder Pipe has been selected for a major water works project.

SPECIFICATIONS issued by the Saginaw-Midland Water Supply Commission call for the manufacture and installation of 254,500 feet of 48 inch pipe . . . 143,230 feet of 36 inch pipe . . . 14,900 feet of 24 inch pipe . . . all operating at a pressure of 130 pounds.

WHEN COMPLETED, this 78 mile water supply line will be capable of delivering 23 MGD to the city of Saginaw and 20 MGD to Midland.

BY SELECTING Lock Joint Prestressed Concrete Cylinder Pipe, the Saginaw-Midland Water Supply Commission assures itself of a pipe line of maximum elasticity, permanent high carrying capacity and an estimated life of one hundred years or more.

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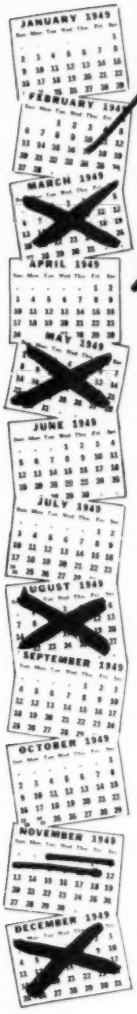

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and you'll be able to *minimize rate increases!*

Think! If you account for only 65% of the water you pump, you have a 35% revenue loss. That's like working for 4 months and 11 days out of each year without any pay! And hundreds of water works account for only 50 to 70% of the water they pump!

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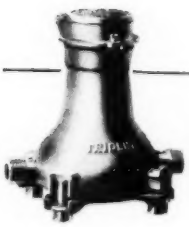

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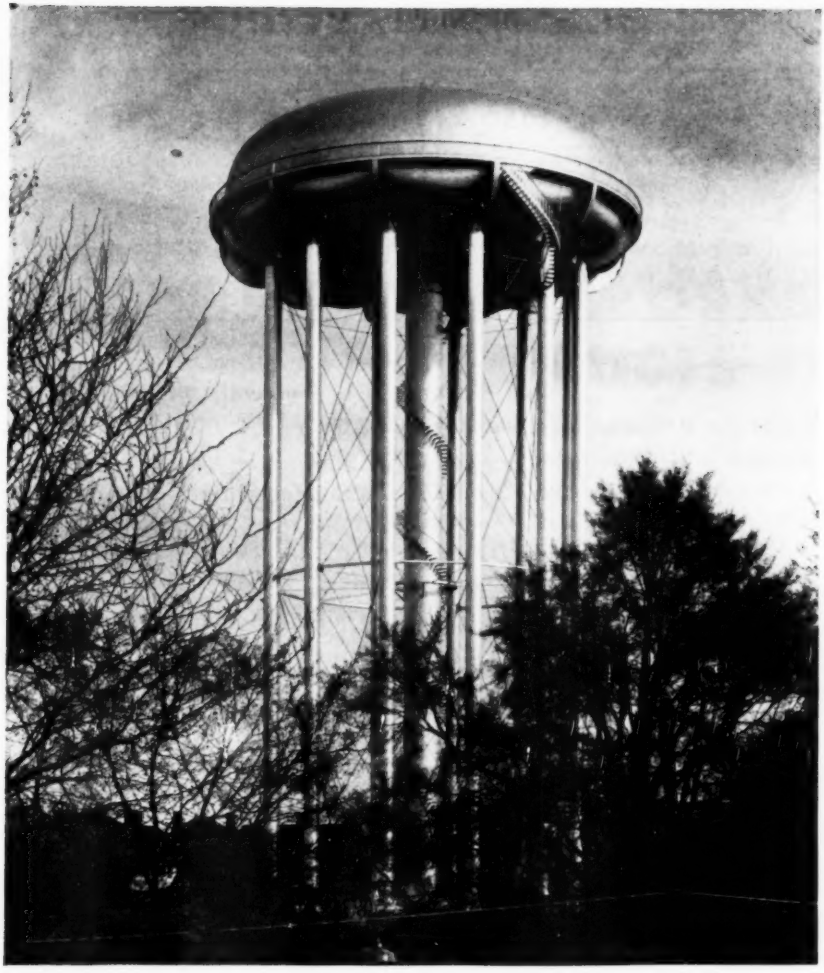

Salisbury Adds Two Horton Tanks

Two Horton elevated tanks, a 1,000,000-gal. (shown above) and a 250,000-gal. unit, were added to the water distribution system of Salisbury, N. C. The new tanks will provide a supply of gravity water to improve pressures in the mains throughout the city.

Write our nearest office for estimates on elevated tanks when making plans for water distribution system improvements.

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COMING MEETINGS

A.W.W.A. 1949 ANNUAL CONFERENCE

Stevens Hotel, Chicago **May 30—June 3**

A legal holiday on May 30 will not affect existing plans.

Reservations must be on standard forms and cleared through the A.W.W.A. office.

February

17—New Jersey Section Luncheon Meeting, Essex House, Newark, N.J. Secretary: C. B. Tygert, P.O. Box 178, Newark 1, N.J.

April

1–3—Arizona Section at Hassayampa Hotel, Prescott, Ariz. Secretary: Mrs Helen Rotthaus, Sanitary Eng. Div., Arizona State Dept. of Health, Phoenix, Ariz. Hotel reservations through the Prescott Chamber of Commerce.

8–9—Montana Section at Johnson Hotel, Great Falls, Mont. Secretary: C. W. Brinck, Montana State Board of Health, Helena, Mont.

20–22—Indiana Section at Lincoln Hotel, Indianapolis. Secretary: C. H. Bechert, Director, Div. of Water Resources, Indiana Dept. of Conservation, 445 N. Pennsylvania Ave., Indianapolis 4, Ind.

21–22—Kansas Section at Bisonte Hotel, Hutchinson, Kan. Secretary: Major C. Hagar, Supt., Water Dept., Lawrence, Kan.

21–22—Nebraska Section at Cornhusker Hotel, Lincoln, Neb. Secretary: John W. Cramer, Partner, Fulton & Cramer, 922 Trust Bldg., Lincoln 8, Neb.

24–27—Canadian Section at Chateau Frontenac, Quebec City, Que. Secretary: Dr. A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 2, Ont.

28–29—New York Section at Mark Twain Hotel, Elmira, N.Y. Secretary: R. K. Blanchard, Vice-President, Neptune Meter Co., 50 W. 50th St., New York.

29—California Section regional spring meeting at Bakersfield, Calif. Secretary: H. C. Medbery, Engr. of Water Purification, San Francisco Water Dept., Millbrae, Calif.

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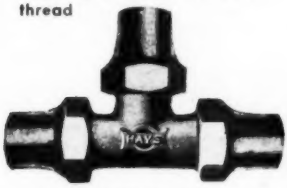
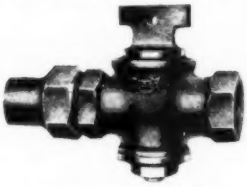


CATALOG No 5622
Hays Tee for copper to copper to copper connection.



CATALOG No. 5050
Hays Curb Stop for iron pipe to copper service connection.

CATALOG No. 5626
Hays Elbow for copper to copper connection.

HAYS

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HAYS Manufacturing Company is one of the largest making a complete line of water service products, and for 80 years has enjoyed the prestige earned by unremitting insistence upon high quality. The HAYS line of fittings and other products is famous throughout the world for easy installation and a long life of trouble-free service.

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CATALOG No. 5610
Hays Two Part Union for copper to copper connection.

CATALOG No. 5605
Hays Coupling for Male iron pipe to copper connection.

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HAYS MANUFACTURING CO., ERIE, PA.

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Journal

AMERICAN WATER WORKS ASSOCIATION

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February 1949
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Financing Water System Development

By Frederick L. Bird

A paper presented on Dec. 7, 1948, at the Southeastern Section Meeting, Augusta, Ga., by Frederick L. Bird, Director of Munic. Research, Munic. Service Dept., Dun & Bradstreet, Inc., New York.

THE successful financing of water system development depends primarily on adherence to certain basic principles of good business management, particularly long-term financial planning and the adoption and maintenance of appropriate financial policies in the operation of the system. Water works men, as experts and technicians responsible for providing their communities with the world's most indispensable public utility, are not merely concerned with the day-to-day operations of their water systems, but have a heavy responsibility for long-term physical planning. It is necessary to forecast the nature and extent of the prospective growth of service areas and the probable trend in the demand for water as well as to assess these factors in terms of need for an increased or possibly a new supply, additional transmission lines and treatment plants, and extensions or replacements of distribution systems. Water officials have to look ahead to ways and means of maintaining, or improving, the quality of the product and the dependability of the service, and it may well be that this physical planning will be very influential in helping a city to attract new industry, business and population.

But to carry out these physical plans requires varying, and perhaps large, amounts of money, the provision of which can no more be left to chance than can the operation and physical development of the system—at least, not if the water system is to pay the bill without placing too heavy a burden on the customers. That is why it is important for financial planning to go hand in hand with physical, or technical, planning and to look even farther ahead. A five- or even ten-year capital budget, revised carefully from year to year, can help to maintain a water system in good condition, expedite necessary system development on a rational basis, and keep the whole program in line with financial resources.

Sound Financing

It is rather pointless and ineffective, however, to try to plan financially for the future development of a system unless it is set up to operate on a business basis and the management is in a position to establish and maintain sound financial policies. Operation on a business basis implies a distinctly self-supporting utility enterprise, with continuity of management, freedom from excessive political interference, financial accounting through a separate fund with a standard municipal utility accounting system such as that recommended by the Association (1), and safeguards against the diversion of system revenues for general city purposes.

The criteria for appropriate financial policies are bound to vary from place to place, depending on local conditions, but the experience of some of the best financially managed municipal water systems suggests several good general standards. First, if it is the objective of a municipality to have its water system operate on a self-supporting basis, what constitutes self-support should be absolutely clear-cut and well defined and plainly reflected in the system's accounts and financial statements. This means that a system's revenues will include payment by the municipality, at reasonable rates, for water used, and that expenses will include not only operation and maintenance, debt service and depreciation (which may be applied to the amortization of bond principal), but also payment to the municipality for services rendered and, probably, a payment in lieu of taxes. Second, a clearly established policy is needed delimiting the use of water revenues for general municipal purposes. Otherwise, it can never be known what revenues may be depended on for planning improvement programs. A very reasonable arrangement is to limit the general government's share to an amount equal to the tax it would receive if the system were privately owned. The system management should be permitted to accumulate depreciation reserves and surplus for use in financing replacements and improvements, and, even if local conditions dictate against rates which will yield much surplus for capital improvements, such rates should be high enough to maintain not only adequate working capital but a modest emergency reserve fund.

These particular suggestions may not be feasible or entirely appropriate in some municipalities, and they certainly do not cover the entire field in which the maintenance of well defined fiscal policies is important, but they will serve to indicate the type of business management that is prerequisite to the most successful financing of water system development.

The methods available for financing the development of any given water system are clearly dependent on the nature of the financial policies adopted and followed for the operation of the system, and, unless these policies are established with the objective of facilitating future system development, the management may find itself handicapped by a very limited choice of method. If, for example, the water system is used as a sort of tax collection agency of the municipality, and water revenues are so intermingled with the general revenues as to be unidentifiable, the management has little opportunity to accumulate funds for replacements and cannot offer the special security of earning power when it

wishes to sell bonds. In other words, thriftless policies, or no well defined policies at all, may be good politics but in the long run can be very expensive.

Water system development is a broad expression that may refer to a number of different types of improvement affecting the whole system. The term includes replacements; extensions of the distribution system; or additions and improvements to supply, storage, pumping, purification, transmission and the like. These three different classes of improvements may, very properly, be financed in different ways. For example, in the extension of distribution systems, the prospective business in the new service area may be so limited or uncertain that the customers or property owners should be charged for all or part of the cost of the extension. In general, however, the financing of system development will be from the proceeds of bond issues, from the accumulation of earnings or from both.

The author heard recently of a large city that had forgotten how to borrow money. This unusual situation very definitely was not a reflection on the city's management, because for seventeen years that city had financed its public improvements without the public sale of a single bond issue. It is not the author's intention to suggest that the financing of water system development should be placed entirely on a pay-as-you-go basis, for it would be unfair to past and present customers to make them pay through their water bills for large new projects designed to serve the needs of the next generation's water users. But it is the soundest policy in the long run for a water system, in addition to paying off its bonds from revenues, to accumulate sufficient reserves to finance replacements and minor, routine improvements. If the management is given sufficient control of its revenues to permit this policy, there is assurance that the system can be maintained continuously in good condition; there will be no need for the financing of deferred maintenance with long-term bond issues, which is not an uncommon practice; and the use of long-term borrowing can be restricted to the financing of costly additions and improvements.

When it does become necessary to issue bonds, a municipality naturally wishes to do so on the most favorable terms that can be secured. Water bonds, because they apply to the financing of an absolute necessity of the community and because they are for a revenue-producing enterprise which can be made to support itself on a sound, stable basis, have good possibilities for being marketed at lower interest rates than the general-purpose bonds of a municipality. How well these possibilities are realized depends largely on the management and fiscal policies of the water system and on the planning and promotion of the bond issue.

The price at which a bond issue is sold is governed by two factors, the condition of the market for municipal bonds in general and the opinion of the bond purchaser or investor about the security of the particular issue. The municipality offering the bonds has little control over the first factor, but it can do a great deal about the second.

Interest Rates

The trend in interest rates has been discussed by the author in a previous article (*2*), but a brief review of the subject may prove useful.

The average interest rates of municipal bonds on the general market are nearly twice what they were in the spring of 1946, when they reached an all-time low. Thus, the financing of water system development must contend with the increased cost of money as well as of materials and labor. The reasons for the increase in municipal-bond interest rates are well known. During the war the supply of new bonds was low, while there was an increase in demand by well-to-do private investors because the rise in income tax rates made the shelter of tax-exempt bonds more valuable. More recently there has been some reduction in income tax rates and the supply of municipal bonds has increased enormously. For many years before the war, state and municipal borrowing ran about $1 billion a year; during the war it averaged about $310,000,000; in 1947 it rose to $2.3 billion and in 1948 to $3 billion. However, in a period of several months in which there is no pronounced trend in interest rates there are nevertheless moderate fluctuations, creating temporary opportunities to sell bonds to the best advantage. It pays, therefore, for the officials responsible for the sale of bonds to make some study of the market, or, perhaps more profitably, to seek the advice of municipal-bond specialists on the timing of offerings.

Since the November 1948 elections, there has been an appreciable lowering of municipal-bond interest rates, which illustrates some of the factors that influence the municipal-bond market. On the one hand, only about $800,000,000 of the more than $1 billion in bonds voted on at the election was approved. This helped to improve the market by removing the fear that the new supply of bonds might exceed the demand at existing interest rates. On the other hand, the re-election of President Truman led many investors to believe that there would be a continuation of federal fiscal policies which might have the effect of stabilizing or lowering municipal bond interest rates. For example, there would probably be a continuation of the policy of keeping long-term government bonds at or above par, and there might be an increase in personal or corporation income tax rates which would make the tax exemption of municipal bonds more valuable. It can be seen, therefore, that conjectural factors enter the picture strongly and preclude any assurance of what interest rates may be a year or only a few months from now.

The factor in determining interest rates which is largely under the control of the individual municipality is the attitude of the investor toward the security for the bonds. The experience of two small cities which recently offered general-obligation water bonds will serve as an illustration. One city had to pay an interest cost of 3.2 per cent for bonds maturing through 1988; the other sold bonds maturing through 1973 on a 2.1 per cent basis. The difference in the length of term accounted for only a relatively small portion of the spread in prices. Both were prosperous, growing communities and there was no difference in their economic prospects, but different fiscal policies were employed in the operation of the water systems and divergent types of security were offered for the bonds. In one city there was no attempt to meet water debt service from water revenues; such revenues were obviously insufficient to service the new bonds; there was no provision for depreciation; the entire balance after operation and maintenance at the close

of each year was transferred to the general fund; and it was evident that utility revenues were depended on so heavily to finance general operations that service of the new debt would create a general budget problem. The other city's water system followed a well defined fiscal plan, including provision for depreciation, payment to the city for services and rental of space, and payment of property and utility taxes. Moreover, although the bonds were unlimited tax obligations of the city, it also pledged itself to pay principal and interest from water revenues and to set rates that would permit it to do so. It is rather obvious, from the results, that these careful arrangements were worth the trouble.

Every reasonable pledge of security should be given to convince the investor that the bonds are thoroughly sound investments. If the water department is set up and protected so that it operates as a stable, self-supporting business enterprise, every possible advantage should be taken of this situation when offering bonds. On the other hand, if the department does not enjoy these favorable conditions, either because of the lack of appropriate financial policies or the absence of adequate statutory authority, it will be well worth while to try to eliminate these handicaps before attempting any large-scale borrowing.

Selection of Bonds

The choice of the type of bond to be offered, classed according to the nature of the security, may very well affect the interest rate favorably or unfavorably. Unfortunately, the laws of some states do not permit much latitude of choice; but if they do, or the legislature can be induced to provide more flexible legislation for water system financing, it makes good sense to use the type of bond which will produce the lowest interest rate.

Three general types of bonds are employed by American municipalities to finance water system development: [1] ordinary general-obligation bonds, for which the faith and credit of the municipality are pledged; [2] revenue bonds, secured only by the earnings of the system and possibly by a mortgage on the property; and [3] bonds secured by a pledge not only of earnings but also of the faith and credit of the municipality. When there is a clear choice, the selection of the financing medium should, logically, be that which offers the strongest security. If the general credit of the municipality is weak, the finances of the water system may be strong enough to dictate the use of revenue bonds. But a financially sound municipality usually can sell its general-obligation bonds to better advantage than its revenue bonds; and the cheapest method of financing a self-liquidating water system, by a municipality whose credit is good, is the use of bonds which carry a pledge both of the taxing power and of earnings.

The use of revenue bonds, or bonds with the combined pledge, requires the services of a genuine financial-planning expert in this particular field and of a bond attorney who is a specialist in these types of bonds. This is important because the technical proceedings involved call for a high degree of precision.

Finally, when a municipality proposes to sell water bonds it must remember that it pays to advertise. If a city wants to secure wide competition in bids, and feels that there are many favorable factors about the water system, its management, its finances and

its plans, and about the community itself, that should justify favorable bids, this information must be placed in the hands of prospective bidders. This should be done sufficiently far in advance of the date set for the sale to give the bidders an opportunity to study the data and to prepare promotional material for their own customers. Since there are thousands of political subdivisions selling or planning to sell bonds, it is too much to expect that bond buyers can keep up to date on all of them; and it would be a misfortune for a municipality to get a poor price for a good product merely because adequate information regarding the quality of the product was lacking.

Thus, when advertising bonds for sale it is good business to send out to a carefully prepared mailing list, and have available for inquirers, not merely the notice of sale and the technical description of the legal security for the bonds, but a prospectus containing the basic facts about the water system and the community. It need not be elaborate or expensive—a few mimeographed pages will serve very adequately if the contents are well chosen and clearly presented. If the water system is an established one rather than a new acquisition, the financial information should, as a minimum, include a statement of financial operations for the past five years, a balance sheet as of the close of the most recent accounting period, a debt statement, a bond maturity schedule and a rate schedule. Additionally, there should be brief explanations of the main physical features of the system, the purpose of the new bonds and the anticipated effect on operations and earnings; a short description of the distinguishing characteristics and resources of the community itself; and brief comment on any aspects of financial management and policy that are pertinent to the security for the bonds.

Summary

To recapitulate, truly efficient and successful financing of water system development—assuming that the technical administration and planning are of high quality—depends on continuity of nonpolitical management; operation of the system as a self-supporting business enterprise with sufficient financial autonomy to permit the maintenance of sound fiscal policies; the accompaniment of long-term physical planning by long-term financial planning; the availability of good bond laws; judicious selection of the borrowing medium and careful planning of bond issues; and really informative public reporting and public relations that will develop and maintain confidence in the administration of a city and its water system.

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Licensing Laws and Practice in the United States

Southwest Section Committee Report

A report of the Special Licensing Committee of the Southwest Section, pepared under the chairmanship of F. L. McDonald and adopted by the Board of Trustees of the Southwest Section on October 10, 1948. Other members of the committee were: C. H. Billings, R. M. Dixon, A. A. Hirsch and C. O. Huntress.

AT the February 1947 meeting of the Board of Trustees, Southwest Section, A.W.W.A., a special committee was appointed for the purpose of reviewing licensing laws and practice with a view toward suggesting basic principles and encouraging a standard type of licensing program.

Results of Survey

After reviewing reports and papers published in the JOURNAL, the committee decided that the best approach to this problem would be to make a study of the various laws and voluntary plans of all states. Letters were written to every state sanitary engineer and answers were received from all but two.

A study of the answers indicated that there were only eight states which, by legislative act, had vested the state health department with some degree of authority over the control of water works operators in the state. These states are: Connecticut, Kentucky, Michigan, New Jersey, New York, Texas, Ohio and West Virginia. A further study revealed that twelve states exclusive of those named above were operating under a voluntary licensing or certification plan, administered either by the state health department or the state water works association, or jointly by both. This left 26 states with no voluntary or mandatory program of any type. (Two states did not report.) Of these 26, quite a number are considering a voluntary program; several have attempted legislation which has failed to pass. Appendix A lists all of the states with a brief comment concerning licensing or certification.

The committee then decided to break down the answers from the states into a study of specific voluntary and compulsory programs for comparison. The programs of several states were selected for study, including two states which had offered legislative bills requiring licensing or certification that failed to pass. Of these states, six made licensing mandatory and seven operated a voluntary program. The following features were studied in these programs: classification of plants, qualifications of operators, composition of examining boards, renewal privileges, revocation powers, "grandfather clauses," fees, financing and penalties.

Some states classified plants according to type of treatment, size and population served. All programs considered experience, education and other qualifications of the applicant. Most had examining boards composed of from three to nine members. Most programs required written examinations. A wide variation on renewal of licenses was apparent, with terms run-

ning from one year to life, together with varied renewal fees. Only four states did not grant revocation powers. Seven did not have a grandfather clause. Five collected license fees, six did not. Practically all programs were carried on by monies available from state health departments or fees, or both. Only four states had penalty clauses making an unlicensed operator illegal. Penalties ranged up to $300 fine. One state affixed a 60-day maximum jail sentence. Appendix B shows this breakdown in detail.

One fact worthy of note was the failure to secure legislation for six mandatory programs. In one state, the bill for the proposed legislation failed because the governor vetoed it on a technicality. In one or two other states, similar bills failed to reach a vote because of the opposition offered by municipal officials. The reason for the failure in tne remaining states was not determined.

An explanation should be made concerning the information missing in certain categories for some states. When the letters were written to the various state sanitary engineers requesting this information, specific questionnaires were purposely not included. This was done for two reasons: First, the committee wished to obtain the general feeling in the states regarding licensing, and this could not be done by means of questionnaires alone. A considerable amount of additional and valuable information was obtained by requesting a factual reply, which, the committee feels, more than justified the lack of specific information from some states. Second, the committee also hesitated to send questionnaires since it has been the sad experience of its members to be plagued by a continued stream of similar time-consuming answer sheets on every conceivable topic, and it was felt that no good purpose would be served by continuing this questionable practice.

On the basis of this study, general recommendations for a standard type of licensing or certification program were formulated by the committee. Acknowledgment is made to the various states having voluntary or mandatory programs, to various articles and reports in the JOURNAL and to the Federation of Sewage Works Assns. committee report on "Qualifications of Sewage Treatment Plant Operators" (1), from which much of the information contained in this report has been freely drawn.

Advantages and Disadvantages

In view of the importance to the health of their customers, and the dangerous consequences of incompetence among practitioners, licensing is required of physicians, midwives, nurses, opticians, undertakers, barbers, beauticians and others, almost without exception in all states, yet the water plant operator, to whose work whole populations are exposed, is generally neglected so far as formal qualifications and licensing are concerned. Food handlers of all sorts must be examined, but the qualifications of the men who furnish the potable water are never thought of. Furthermore, persons in many professions and trades, such as lawyers, engineers, surveyors, plumbers and electricians—some without the remotest relation to public health, but requiring some degree of public trust—are licensed as a measure of protection. The work of the water plant operator frequently calls for some knowledge of these trades, so that, considering his public health re-

sponsibility at the same time, it seems logical, from any point of view, that some system of licensing or certification is in order.

It is generally accepted that certification or licensing of water superintendents, operators, chemists and other water works personnel in a responsible position is advantageous not only to the individuals concerned but also to the public, local officials and the state health departments.

When properly educated to the need, the general public will usually support a certification plan for water works personnel as a safeguard to health, and to secure the best results from a plant which is paid for and maintained with public funds.

Local municipal officials should be amenable to state certification since it will protect the administration against the demand of politicians for the appointment of the inexperienced, and will result in having qualified men remain on the job, with an attendant decrease in plant operating costs. A higher type of personnel can also be attracted to positions which are not subjected to political pressure. The fact that political expediency often enters into the appointment of municipal employees should not be used as an argument in favor of licensing. This committee believes that the power to employ local men should remain within the municipal government, with only sufficient restraint to insure that men of adequate qualifications are employed.

From the standpoint of the state health department, certification will contribute greatly to better public health protection and to a simplification of control of water treatment plants and systems. It will greatly reduce the burden of training new men, as a qualified operator is usually content to remain on the job to the extent that he has job security through a certification program.

The principal benefit of certification to the operator is that he is raised to a professional or skilled status. This improvement in status can only lead to better salaries. Because of the removal of politics, the operator is assured of a more permanent position and will therefore have a more progressive attitude toward his work.

In summation, any plan for the certification or licensing of men charged with the supervision or operation of water systems and water purification plants would affect the superintendents and operators themselves, the mayors and city councils or commissions and city managers, the state health department and its subordinate units, and finally the public.

Edward R. Stapley, Dean, College of Engineering, Oklahoma A. and M. College, has very ably summed up the advantages and disadvantages to those affected (*2*):

> Considering first the individuals to be licensed, the advantages and disadvantages might be listed as follows:
>
> The case for—to encourage men to improve themselves; to stabilize employment by reducing personnel changes; to increase respect of municipal officials for departments and plants; to insure better salaries being paid; to attract higher-grade men to the position; to awaken more public interest in systems and plants.
>
> The case against—too much red tape in making a living now; too much government regulation; extra expense for license and renewal fees when pay is already too small; danger of political control of licensing body; older men with little school training placed at a disadvantage in examination; employees of private companies feel they have nothing to

gain in the way of security or pay to balance extra expense and trouble.

Next take the mayors', city councils', commissioners' and city managers' viewpoint.

The case for—competent operating personnel guaranteed; superintendents, being responsible for systems and plants and quality of products, will also be certified as competent; city will benefit from increased interest of employees in training; public health of community protected; better economy in use of city funds; better care and maintenance of plants and equipment; excuses furnished for refusing to employ job-seeking supporters.

The case against—superintendents should be executives rather than schooled in sanitation, and boards cannot set up examinations to determine this quality; licensees will lose interest in continuous self-improvement; security of position will tend toward inefficiency; interference with present Civil Service systems; restricts right to hire and fire . . .; decrease opportunity to pay off political debts.

For the state health department the case seems to be rather one-sided according to the viewpoint of health department officials.

The case for—superintendents and operators would have at least a minimum knowledge of their jobs; continuity of plant operation; greater familiarity with health department requirements; increased control of personnel in plants for the safeness of whose products they were largely responsible; greater protection to public health.

The case against—apparently none.

Of all groups the general public is perhaps least interested, but should it be?

The case for—maximum protection for community health; increased potability of water supply; proper operation of city's investment in plants and equipment; sensible economy in expenditures from city funds; reduced tendency of irresponsible politicians to make political footballs of plants and systems; stabilized municipal government; increased utility revenues.

The case against—too many laws already; danger of political control of licensing board or body.

With the foregoing arguments in mind, it would seem to me that any fair-minded judge would declare the "Ayes" have it.

Certification Versus Licensing

According to the dictionary, a license is a permit or formal permission from a constituted authority to do something, as to carry on some business or profession, and a certificate is a written testimony certifying to the truth of any fact, or to status, qualifications and so forth—a document attesting that one has met the specified requirements of a course, school or examination.

In the report on "Qualifications of Sewage Treatment Plant Operators" (1) a distinction is made between certification and licensing:

> Licensing in the true sense requires an official listing of available personnel from which communities within a state must pick a candidate. The certification method involves approval of local men and permits home rule.

This thought expresses the feelings of this committee on the distinction, and it is believed that certification is much the better word when used in the light of the above meaning. The committee also believes it is important that a certified local operator be employed to operate a water plant, since fairly close liaison is necessary between the operator and local officials in matters of finance. A local operator will ordinarily have a greater chance of securing local municipal cooperation and public acceptance than an outsider. The water works personnel must be in harmony with the municipal adminis-

tration in order to obtain cooperation and to secure the best operating results.

Basic Principles of Certification

The committee feels that there are certain fundamentals to be observed in a general consideration of certification. An examining board should pass on the qualifications of the water works operators. The members of this board should probably be appointed by the state health department upon recommendation of the state water works association. It should be composed of leading men in the field, representing the water works operators, the state college or university and the health department. The board should have authority to issue certificates to those of suitable proficiency; to publish lists of those certified; to bring suit where necessary to enforce compliance with the law; and to formulate rules and regulations. The actions of the board should be a matter of public record. It should not have the power to dictate the appointment of particular operators.

Certification should be mandatory. This conclusion is substantiated by the number of mandatory programs in successful operation, those states which have tried unsuccessfully to secure legislation and the number of states replying that legislation will be necessary sooner or later. Voluntary certification provides very incomplete coverage of operators, as it reaches mainly the ambitious ones, who constitute the least problem. The rules and regulations governing qualifications of operators should be made compulsory for all operators. All operators should be certified or licensed and all other operating personnel should be encouraged to obtain a certificate. (The term "operator" is defined specifically in a later section.) The certificate or license should be subjected to renewal at specified lengths of time and should be subject to revocation for just cause only after a public hearing before the examining board. The law should have teeth in it.

There must be some provision for a broad general training program for new operators as well as present ones in order that all operators will have the same opportunities for instruction and will at least be grounded in fundamental water works practices. This training program should be in the form of short schools for water works operators sponsored by the state college, university or both in cooperation with the state health department and water works association; in-training or other classes conducted by the state department of education through its division of vocational education; or correspondence courses; or perhaps a combination of these. Training inside the plant conducted by certified personnel would add to the educational efforts. The rules and regulations should specify that this training course must be taken prior to or concurrent with the certification examination, or within a specified length of time after the examination is given if the courses or schools are not available at the time, or if other circumstances warrant.

Recognition must also be given to the classification of plants and the qualifications of operators as discussed below.

Classification of Systems

The committee believes that water works should be classified on some workable basis. This is necessary in

order that qualifications can be set up for superintendents, operators or both. It is an established fact that the water works superintendent has a job of great responsibility, not only from a public health but from an economic standpoint. The investment represented by the water works is often the largest single investment in a community, whether it be privately or publicly owned. Some states have found it desirable to classify plants or systems, and have based this classification on source of supply, plant and system capacity, type and degree of treatment, population served, quantity supplied and location, and on the skill, knowledge and experience required of the operator. While all water works men have a certain degree of responsibility, it must be recognized that the larger the system or population served, the greater the responsibility. This is also true of the surface supply with its pollution hazards exceeding those of the well supply.

The committee believes that the most logical classification would be on the basis of population served, type of treatment and source of supply. It realizes that the classifications suggested are arbitrary but believes that they will meet all needs with minor modifications by the respective states. It therefore suggests classification as follows:

Class A plants: surface supply (including springs)—all plants where chemical feeding, mixing, coagulation, settling, filtration, disinfection, or combination thereof, or softening is practiced and serving over 10,000 population; well supply—all plants where chemical feeding, mixing, coagulation, settling, filtration, disinfection, or combination thereof, or softening is practiced and serving 10,000 or more population, or all other plants or systems serving over 25,000 population, regardless of treatment.

Class B plants: surface supply (including springs)—all plants where chemical feeding, mixing, coagulation, settling, filtration, disinfection, or combination thereof, or softening is practiced and serving less than 10,000 population; well supply—all plants where chemical feeding, mixing, coagulation, settling, filtration, disinfection, or combination thereof, or softening is practiced and serving less than 10,000 population, or all other plants or systems serving 5,000–25,000 population, regardless of treatment.

Class C plants: All plants and systems not covered under Classes A and B.

The superintendent, chief operator and chief chemist of a plant should hold a grade certificate corresponding to the class of plant. It should be mandatory under any program that the superintendent and the chief operator or the person in responsible charge hold this certificate, as well as all operators who would be on duty without the benefit of supervision and thereby have to exercise individual judgment. All other operating personnel should be encouraged to obtain a certificate at least for the grade below that of the superintendent or responsible person.

Another recent, radically different but advantageous classification, useful for purposes of certification, consists of a brief descriptive phrase to characterize a plant according to the basic processes involved, in this way avoiding much of the arbitrary nature of an A, B, C designation. Typical examples of the nomenclature used are: "ground water supply without treatment," "treatment plant for ground water with aeration and sedimentation

for iron removal and disinfection" and "purification plant, chemical softening, settling, filtering and disinfecting surface water." Definitive classification of this sort enables examinations to be composed to fit the case for each operator without inquiring into his knowledge of processes extraneous to him. So far as the public is concerned, the definitive statement of the operator's certified field of coverage is considerably more significant than the code letters A, B, C. Incentive for the ambitious operator is provided by a special examination, much more comprehensive than the foregoing, to earn the title "First-Class Water Works Operator." However, a counterpart of this system, for sewage works classification, has been in use only for a short time, and while working adequately, its adoption elsewhere should be made only after due consideration.

Qualifications of Operators

The term "operator" is used to apply to a person under any local title or other designation who is now or shall hereafter be in direct general charge of a public water treatment plant or public water supply system, and who is responsible for and supervises the condition, operation and effectiveness of the structures comprising the plant or system, and who is responsible for the safety or quality of the water delivered from the plant or system; or a shift operator upon whom any of these responsibilities devolves during working hours.

The certification of operators is based on the skill, knowledge, experience, education and character that a person must have to operate a specified class of plant successfully, to maintain it economically and to safeguard public health. Operators must possess a sufficient degree of application, initiative and judgment in order to secure satisfactory operating results. They must be alert and have ability and experience in handling men and dealing with the public. The committee suggests, in addition to the above, the following qualifications:

Grade A: Every applicant should [1] be in good physical condition; [2] submit satisfactory evidence of at least five to ten years' responsible, successful experience in water works operation or management in plants of similar type and capacity, including the administration, production, treatment, control and distribution phase; and [3] pass an approved written and oral examination. His record should show attendance at water works operators approved-type training courses and district and state water works meetings. The number of instructional hours and the rate at which they can be earned should be specified.

A college degree from a recognized course of study in sanitary, public health, chemical or civil engineering, or in chemistry if it has included acceptable courses in sanitary sciences, and postgraduate work in the above should be considered as a substitute for part of the experience requirement. Provision should also be made so that less than a college education can be evaluated by the examining board along with experience in determining an applicant's qualifications. Experience in skilled trades likely to be useful in operation should be considered.

Grade B: Every applicant should [1] be in good physical condition; [2] submit satisfactory evidence of at least three to five years' responsible, successful experience in water works operation and management, including the

administration, production, treatment, control and distribution phase; and [3] pass an approved written and oral examination. His record should show attendance at water works operators training courses and district and state water works meetings. The number of instructional hours (less than that required for Grade A) and the rate at which they can be earned should be specified. Education and skilled trade work as outlined under Grade A should be considered as a substitute for part of the experience requirement.

Grade C: Every applicant should [1] be in good physical condition and able to read and write; [2] submit satisfactory evidence of at least two years' successful experience in water works operation; and [3] pass a written or oral examination, or both. His record should show attendance at training courses (less than that required for Grade B) as outlined under Grade B above.

Any applicant should be permitted to apply for, and be granted if qualified, a certificate for a grade higher than that required for the class of plant he is presently operating.

General Training Program

The public and sometimes the industry seldom consider the duties and problems confronting the water works superintendent or the training and experience necessary for the efficient exercise of his duties. While experience is the greatest teacher, adequate technical training is fundamental. Unfortunately a technically trained superintendent cannot be expected for small systems as long as present small salaries continue.

The committee feels that some discussion should be devoted to the facilities which are available, or which might be made available, for a general training program for water works operators, and to the method of administering such a program.

In Texas, the Texas A. and M. College, through the industrial extension service, provides three itinerant teachers who conduct classes at night for small groups of water works operators at centrally located points throughout the state. In February of each year the college conducts a short school for water works operators. In Louisiana, a short course is held early each summer at the state university, and an itinerant program of instruction is conducted by the state department of education through the division of trade and industrial education. Similar courses are being offered in the state colleges of Oklahoma but are being carried on only to a limited extent in Arkansas.

The committee recommends that more short courses and related facilities be made available to water works operators in the various states. The courses should not last more than a few days but should be held frequently since operators of most small plants are unable to attend for a longer period of time and the material presented in a limited period can be more easily retained by the operator. Traveling instructors are most helpful, because local conditions can be observed directly and aid given in the way best suited to a particular operator.

In many states there are a number of district water works associations whose membership includes operators from towns within a distance of from 50 to 100 miles. These district associations have weekly, monthly or quarterly meetings. At each of these meetings, a portion of the time should be allotted to the general training program. The instructor could be a sani-

tary engineer from the state health department, a prominent water works operator, a professor of sanitary engineering or other qualified person.

Experience has shown that, despite the good work being carried on by short courses given by state colleges and education departments or by water works associations, much additional training is desired. Correspondence courses can fill a lack of more formal education. Correspondence courses in water works practices are or should be made available at a reasonable cost through the extension service of state colleges and universities. These courses should be specially prepared by water works men. Lacking these facilities, private correspondence schools offer courses for water works operators which might be quite valuable for this purpose. The contents of such courses should be approved by the state health department and water works association before being undertaken as training courses.

Not the least of the available means for providing special training for operators are the books and manuals which have been published. The data in various published material might well serve as a special home course of study. The committee recommends strongly the reading of the technical journals that are available through the national Association. A list of the simpler textbooks that can be used for home study can be obtained from any state health department or water works association.

Not to be overlooked is training inside the plant conducted by qualified personnel.

The committee has not considered the subject matter which should be included in the training program but would like to emphasize the need for more stress on economical operation and maintenance—for instance, the control of corrosion and tuberculation in the distribution system.

The committee feels that a broad, general training program is of such importance that it should precede, or at least be carried on simultaneously with, a certification program. The two should be separate; one for educational purposes, and the other to determine the proficiency of the operator and to certify to that proficiency by giving him a certificate. The committee feels that to make certification mandatory without giving considerable thought to training is a plan fraught with danger. Adequate training of the operator should be paramount, and certification should be secondary. Otherwise, the certificate can mean nothing, and the public is given a false sense of security which will, in turn, reflect upon the certifying body.

Another pitfall to be avoided in the consideration of a training program in conjunction with a certification program is the likelihood of falling into a habit of offering to the operator just sufficient training or coaching to pass the examination. If a narrowly coached operator is permitted to pass an examination, he has been treated unfairly, for he may think he is qualified by training, whereas adequate training has not been given him. If this condition is allowed, the operator has been cheated and the public has been cheated.

Certification Examinations

All operators who are not covered by a grandfather clause in the basic law should be required to take an examination after they have been tentatively approved on their basic education and experience, before final approval is given to their qualifications.

Examinations should be held at least annually, at places designated by the examining board. Operators failing to pass the examination should be entitled to at least one re-examination without additional cost. Operators covered by the grandfather clause should be encouraged to qualify for certification.

The examination should be both oral and written. Practical examinations should be considered, at least in the lower grades. The committee believes that the oral portion of the examination should carry greater weight than the written portion, because many operators cannot put on paper the things that they actually know about operations. The written portion of the examination should be straightforward, and the questions should consist of short answers, true-or-false, multiple-choice, or similar types of questions. The subject matter should pertain specifically to water works operation and maintenance and to fundamental theories of water treatment and practice. The examination should not be so easy that it becomes a mere formality. The operator should have to work for and earn his certificate. It is a badge of competence that he should be proud of and delight in displaying.

The operators should be told in advance the character and nature of the examination and, in general, the material to be covered, so that much confusion and unnecessary worry can be avoided. However, this should not be done at the expense of the training program in such a way that the training program will resolve itself into a coaching class to prepare the operators for specific examination questions.

The subjects on which the various grades of operators should be examined are listed below:

Grade A: An applicant for the Grade A certificate should be examined on the administration, production, treatment, control and distribution phases. He should be expected to have a considerable amount of detailed information at hand covering the entire field of water supply and treatment.

The examination covering the surface supply grade should naturally stress problems dealing with surface supplies. Under the well classification, production of ground water should be stressed along with treatment problems involved in connection with a well source of supply.

Grade B: An applicant for the Grade B certificate should not be expected to know as much or to answer as highly specialized questions as the Grade A applicant. The examination should cover the same general field as outlined under Grade A above.

Grade C: An applicant for the Grade C certificate should be expected to have specific knowledge of the procedure in operating and maintaining plants where no treatment other than chlorination is involved. He should have such a limited, general knowledge of administration, production, control and distribution as is necessary for operating a small water supply.

Certification Law Provisions

There are a number of provisions which the committee feels are essential to any law providing for the licensing or certification of water works operators. Such a law should be brief and should not set forth detailed regulations. It should include:

1. Definitions of operator, water treatment plant and water supply system.

2. A statement that all public and private institutions, cities, towns, coun-

ties, commissions, or other municipal districts or subdivisions, or any person, firm, corporation or governmental agency operating a water treatment plant or system serving more than ten connections or buildings should be subject to the law and regulations.

3. A statement authorizing the appointment of an examining board whose membership is defined and limited, with authority to set up regulations to govern certification, determine qualifications of operators, classify plants, conduct certification examinations and investigations, and issue certificates and renewals. The public health laws of some states permit the state health department to issue regulations governing water works operators. In most states the state health departments have authority to promulgate and enforce rules and regulations for the proper operation of water systems and water treatment plants. The licensing and certification programs have been based on the protection of public health. Epidemics of disease directly traceable to contaminated public water supplies have given impetus to the adoption of a program of legal certification of operators in many states. While the public health problems involved are of paramount importance in requiring legal certification, the economy and efficiency of plant operation should offer additional stimuli for promoting this program. In most states certification authority is delegated to the state health department. Whether or not this is a natural development or one of economics the committee does not know. It believes, however, that certification authority is a problem of administration which should be left to the individual state.

4. A statement that all water works plants and systems shall be operated by trained individuals whose qualifications have been certified by the board. Provisions should be inserted in the law or regulations covering temporary certification. A temporary certificate should be issued for a limited period and should not be renewable.

5. A provision regulating the renewal of certificates under specified conditions and at specified intervals.

6. A statement delineating the method of financing the entire certification or licensing program. Certification and renewal fees should be small.

7. Provisions for reimbursing examining board members for travel and time spent on official business. (The committee feels some compensation should be made to the members of the board, as it has been a burden in the past, for many members, to serve on examining and certification boards without any compensation.)

8. A clause empowering revocation for negligence, dereliction of duty or incompetence, after a public hearing to show just cause.

9. A "grandfather clause" which will permit an operator to continue to hold his same position as long as no important changes are made in the plant or system.

10. A penalty for violation of the law or the rules and regulations by the operator or the municipality or owner of the water plant or system. In addition to monetary penalties, removal of road signs and publication of official notices in the press could be included. A permit to furnish culinary water to common carriers engaged in interstate and foreign commerce should be subject to withdrawal, as the U.S. Public Health

Service standards plainly specify that water supplies and treatment plants shall be under the direction of qualified operators.

11. An enacting and constitutionality clause.

Conclusion

Experience has shown that any changes in an existing state program of this nature require slow development and gradual fulfillment to be successful. Standardization of the administration of the program might not be desirable because of varying conditions in different states. This report, however, should be presented to each state water works association for consideration. After the states have studied the report and have reached a decision concerning the principles embodied therein and after a majority have signified that a uniform program is desirable, a committee should be formed to give assistance and guidance in promoting this program.

It is the feeling of the committee that this report contains most of the principal points which should be embodied in any program launched in behalf of legislative certification or licensing.

References

1. Qualifications of Sewage Treatment Plant Operators. Sew. Wks. J., **18**:147 (1946).
2. STAPLEY, EDWARD R. Licensing of Plant Operators and Superintendents. Jour. A.W.W.A., **30**:78 (Jan. 1938).

APPENDIX A

Status of Licensing and Certification Legislation

The information contained in this Appendix was compiled in November 1947 and was partially revised in August 1948.

Alabama. May adopt voluntary certification in future.

Arizona. No information.

Arkansas. Voluntary license—three grades based on treatment and population. $1.00 fee charged. Renewal two years ($1.00 fee). License may be revoked. No grandfather or penalty clauses. Board of five appointed for six-year term by water and sewage conference; one representative from board of health, one from university and three from conference. Financed by fee and state board of health.

California. Voluntary certification—three grades. Legislation proposed on several occasions.

Colorado. Considering plan for licensing regulations.

*Connecticut.** Law states that qualifications of operator subject to approval of state department of health. Qualifications set up by department of health regulations.

Delaware. No state program.

Florida. Certification plan voluntary, operates under Florida Water and Sewage Operators Assn. $1.00 fee charged. Examining board of nine (three-year term): chief sanitary engineer, state board of health; two members from university; six members from Water and Sewage Assn. Four grades of certificates, renewable every three years by: [1] re-examining operator, [2] discretion of examining board or [3] completion of two out of three short courses. No grandfather or penalty clauses. Financed by fee ($5.00 to nonmembers). No revocation.

Georgia. Voluntary certification. Program conducted by Georgia Water and Sewage Assn. Certificates in three different grades offered. System has proved to be advantageous.

Idaho. No law or operating plan for licensing.

* State law.

Illinois. Certificates of competency issued. Plan is voluntary. Four classes of certificates, depending on education and experience. Renewal one year. Legislation on licensing has been unsuccessful. Examining board of five: chief sanitary engineer, state board of health; professor of university; and three water works operators. Appointed by board of health for unlimited terms. No revocation. No grandfather or penalty clauses. No fee. Financed by health department.

Indiana. Does not believe voluntary certification is answer. Licensing should be by act of legislature. License law passed both houses in 1945 but was vetoed on technicality. Revised bill will be introduced in 1949.

Iowa. Planning voluntary program by state board of health, colleges and A.W.W.A.

Kansas. Believes plan of licensing desirable.

*Kentucky.** Basic law gives state board of health powers of providing standards of qualifications and issuing certificates. Has not been made mandatory because of grandfather clause. Five classes of registration certificates, based on type of treatment and control, and population served. $2.00 fee charged. Certificate may be revoked. Renewal two years ($1.00 fee). Financed by fee.

Louisiana. Voluntary certification. Certificates issued by Louisiana Water and Sewage Conference on recommendation of examining board. Five-man board consists of representatives from state board of health, state university engineering department, state department of education and two from conference; members serve four years. No revocation. No grandfather or penalty clauses. $1.00 fee. Renewal three years ($1.00 fee). Financed by fee.

Maine. No state program.

Maryland. State board of health can require appointment of approved operator if satisfactory operating results not being obtained. No demand for licensing program now.

Massachusetts. Positions in most municipalities are under state civil service.

*Michigan.** Certification mandatory. State board of health classifies plants. Board of examiners gives examination. Board consists of three members: one from bureau of engineering and at least one plant operator. No fee. Certificate can be revoked. Four classes of plants: F (filtration), D (disinfection only), M (miscellaneous) and T (bacteriological laboratory for D plants only). Classes F and D subdivided by plant capacity. Operator must hold certificate comparable to plant he is operating. Physical examination required. Grandfather and penalty clauses. Financed by state board of health.

Minnesota. Voluntary certification being considered by state board of health.

Mississippi. No state plan but believes licensing good idea.

Missouri. Voluntary system works well; doubts if legislation would pass at this time.

Montana. No laws or regulations.

Nebraska. No laws or regulations.

Nevada. No program but believes licensing has advantages.

New Hampshire. No requirements for licensing.

*New Jersey.** Licensing mandatory. Now operates under three laws. Fee ($5.00) goes to state treasury. Costs paid by state department of health. Examining board of eight (one-year term): three from state department of health and five from water and sewage plants. Revocable. Penalty and grandfather clauses. Annual renewal ($5.00 fee). Full-time services of engineer required for operation of law.

New Mexico. Because of population and terrain, state favors extension courses, leading to certificate of proficiency. Costs are too high to carry out such program at present.

*New York.** Mandatory certification of qualifications under regulations of state public health council. Three grades based on type of plan and population served. Education and experience speci-

* State law.

fied for each grade. Health council may require applicant to take examination if it sees fit. Grandfather clause.

North Carolina. Voluntary plan. Certificates of competency issued in three grades: A, B and C for purification plant operators, and C for well and unfiltered surface supply operators. Board consists of three operators, one superintendent and one engineer from state board of health (five-year term). Examinations by board with certificates issued by state board of health. Revocation clause. Financed by Water Works Operators Assn. (Licensing bill, unsuccessful in 1947, had following provisions: state board of health control; classification of plants by size, type and location, excluding untreated well and spring supplies; grandfather clause; certificate revocable; examining committee; penalties; state board of health to defray costs.)

North Dakota. Voluntary Certification plan not active during war years but to be operative in 1949.

Ohio. Rules and regulations of state department of health same as law. Health department carries on mandatory certification. Exams are given in three classifications. Plants are classified. Board of examiners (five members) appointed by state department of health; sanitary engineer, state department of health; water plant operator; sewage plant operator; and two engineers. Certificates are revocable. No fee. Grandfather clause. No penalty. Feels that position would be much stronger if principles were incorporated into law. Operators enthusiastic about program.

Oklahoma. Resolution adopted in January 1948 by state. Water and Sewage Conference set up voluntary program for certification and licensing of water and sewage plant operators.

Oregon. Planning voluntary program by state board of health, colleges and A.W.W.A.

Pennsylvania. No information.

Rhode Island. No state program.

South Carolina. Voluntary certification program conducted by State Water and Sewage Works Assn. and state board of health. Four grades issued to qualified personnel who take course of study and pass examinations. Approximately 75 per cent of operators have certificates. Believes legislation ill advised at this time.

South Dakota. No state program.

Tennessee. Voluntary certification by department of health. Plants divided into four groups based on treatment and population. Certificate based on experience, education and examination. Revocation and grandfather clauses. No penalty. No fee. Financed by health department.

*Texas.** Certificate of competency issued by state board of health. Law passed in 1945, and rules and regulations adopted essentially same as in voluntary program. Mandatory certification based on experience and education. Credit given for short courses and extension courses of Texas A. and M. College. Certificates in three grades—A, B and C—with four divisions under A and B covering administration, control, distribution and production. C is general. Grades B and C divided into well and surface supply. Resolution of state board of health sets up workings under law. Five members of A grade form advisory committee to act on eligibility. No fee charged. State health officer appoints advisory committee on sewage, which works the same as for water. No revocation or grandfather clauses. Penalty clause. Financed by board of health.

Utah. No state program.

Vermont. No state program.

Virginia. Not sure legislation desirable for state.

Washington. No licensing program. Department rules and regulations require competent operators. Believes voluntary licensing necessary prior to legislation.

*West Virginia.** Registered with, and certified by, state department of health. Mandatory licensing regulation (promulgated by department of health) has following provisions: classification of plants

* State law.

on population and treatment basis; written and oral exams on request; education and experience 20–40 per cent, examination 60–80 per cent. Revocation of license for cause. No fee. Penalty clause. No grandfather clause. Program well received and beneficial.

Wisconsin. Licensing legislation unsuccessful before war. (Proposed legislation provided: three classes of operators; examining board of six: state sanitary engineer, two from University of Wisconsin, one water plant superintendent, one sewage plant superintendent and one municipal official (two-year term); grandfather clause; permits revocable; $5.00 fee charged; penalties; board of health may prescribe rules, regulations and qualifications; licensing mandatory; renewal one year for $2.00 fee.)

Wyoming. Limited number of plants. No licensing program contemplated.

APPENDIX B

Analysis of Licensing and Certification Plans

The information contained in this Appendix was compiled in November 1947 and was partially revised in August 1948.

Arkansas

Classification of plants: Three grades, based on population served and treatment.

Qualifications of operators: Grade A one to ten, Grade B two to five and Grade C two years' experience, depending on extent of education.

Remarks: Each grade has five divisions: education and experience; source and pumping; treatment and filtration; distribution and metering; and general practice and finance. Plan was not very successful until district conferences were organized.

Florida

Classification of plants: None.

Qualifications of operators: Grade A—B-certificate plus three to ten years' experience, depending upon education and short schools attended; Grade B—C-certificate plus one to six years' experience depending upon education and short schools attended; Grade C—six months' experience plus elementary school; Grade D—no requirement.

Remarks: A-, B- and C-certificate holders must have knowledge of water treatment and access to laboratory for fundamental plant examinations. D holders must have knowledge of chlorination only. Florida has not pushed for compulsory plan as many operators are not certified.

Illinois

Classification of plants: None.

Qualifications of operators: Grade AA—six years' experience and four years of college or equivalent; Grade A—five years' experience and four years of high school or equivalent; Grade B—three years' experience and grammar school education or equivalent; Grade C—one year's experience and grammar school education or equivalent. Experience or course in treatment plant operation can be substituted for education requirement.

Remarks: Legislation has failed several times. There are now 365 certificates in force.

Kentucky

Classification of plants: Three classes, based on population served and treatment. Top two are classified as unrestricted or as restricted to specific plant. Third class is restricted to plant.

Qualifications of operators: Education and experience credit varies from 40 per cent for first class to 10 per cent for third. Training credit earned on education varies from 10 to 20 per cent, depending on college degree. Credit can be given for partial education by examining board. Experience credit is earned at rate of 2 per cent a year, beginning

when certified as operator in next lower grade.

Remarks: Basic law empowers state board of health to provide standards of qualifications and issue certificates. Program has not been made mandatory because of grandfather clause.

Louisiana

Classification of plants: Three classes, based on population served and treatment.

Qualifications of operators: First class one to ten years' and second class two years' experience, depending on education; third class no experience.

Remarks: Board is empowered to establish rules and regulations on conduct of examination.

Michigan

Classification of plants: Four general classes, based on treatment. Top class has three divisions, according to size and type of plant; second class has two divisions.

Qualifications of operators: 5–90 credits based on education and 10–20 credits for advanced degree, short course and special courses; 1–70 credits based on positions held in various types of plants.

Remarks: Applicants are examined in four divisions: education, experience, character and any or all phases of treatment plant operation. Certificates are hard to get; 30–40 take examination each year and perhaps 50 per cent pass.

New Jersey

Classification of plants: Department of health may adopt classifications based on plant or system capacity, quantity supplied, treatment, source of supply, method of distribution and so forth.

Qualifications of operators: Department of health may adopt rules and regulations on qualifications for admission to examinations.

Remarks: Operation of law requires one engineer full time and considerable clerical help. There were 357 plant and 390 system operators (all grades) as of June 30, 1947.

New York

Classification of plants: Three grades, based on population served and treatment.

Qualifications of operators: Grade I—one to five years' experience, depending on college education or courses in water purification, or both; Grade II—one to three years' experience, depending on high school education or courses in water purification, or both; Grade III—one year's experience or course in water purification.

Remarks: Law authorizes public health council to enact sanitary code which includes regulations on qualifications of water treatment plant operators.

North Carolina

Classification of plants: None. (Proposed law would authorize state board of health to classify plants by size, type and location, and by skill, knowledge and experience required of operator.)

Qualifications of operators: Class A—B-certificate plus two to six years' experience, depending on education; Class B—C-certificate plus one to six years' experience, depending on education; Class C—zero to two years' experience, depending on education and training schools attended. (Class A, B or C for water purification plant operator and Class C for well and unfiltered supply operator.)

Remarks: Proposed legislation failed in 1947. Law would not require untreated well or spring supplies to have certified operator.

Ohio

Classification of plants: None.

Qualifications of operators: Class A—six years' experience (or engineering degree) and certificate of registration under Engineers and Surveyors Registration Act (latter provision has been amended to permit B-certificate holder to take Class A examination); Class B—engineering degree or three to six years' experience, depending on education (high school and above); Class C—six months'

to six years' experience, depending on education (grade school and above).

Remarks: Department of health has authority to exercise general supervision over operation and maintenance of water treatment works and to enact regulations relative to such work. This is same as law but it is believed position would be stronger if principles were incorporated in enactment of legislature. Changes in regulations are proposed: only individual in charge would be required to have certificate, but others would be encouraged to obtain it. One official spends great deal of time on program. Total of 517 held certificates as of June 1941.

Tennessee

Classification of plants: Four groups, based on population served and treatment.

Qualifications of operators: Group A—one to nine years' experience, depending on education (high school and above); Group B—one to seven years' experience, depending on education (grade school and above); Group C—one to four years' experience, depending on education; Group D—one year's experience. Attendance at operators schools is considered as operation experience.

Remarks: Credit for certified operator given in rating program has stimulated certification. Total of 180 operators from 207 supplies have received certificates of competency.

Texas

Classification of plants: None.

Qualifications of operators: Grade A—120 hours of instruction, five to eight years' experience, depending on education; Grade B—40–80 hours of instruction, one to three years' experience, depending on education; Grade C—zero to 40 hours of instruction, one to two years' experience. (Instruction credit earned at rate of 20 hours for short school and two hours for each regional meeting.) Grades B and C subdivided into well and surface supplies; Grades A and B (both well and surface) divided into administration, production, control and distribution.

Remarks: Program was voluntary until 1945, when it was made law. Program is set up under board of health regulation. Temporary certificate may be issued for one year; A-certificate is for life, B for five years and C for three years. Total of 2,750 men are certified. Program has been very effective in raising standards. There are 29 district associations.

West Virginia

Classification of plants: Three classes, based on population served and treatment. Top two classified as unrestricted or as restricted to specific plant; third class restricted to specific plant.

Qualifications of operators: First class—three years' experience, with education and experience counting 40 per cent and written exam 60 per cent; first class (restricted)—two years' experience, with education and experience counting 30 per cent and written exam 70 per cent; second class—one year's experience, with education and experience counting 20 per cent and written exam 80 per cent; second class (restricted) and third class—three months' experience, with written exam counting 100 per cent. Training credit earned on education varies from 10 to 20 per cent, depending on degree: 2–4 per cent allowed for each year completed, depending on course taken. Experience credit earned at rate of 5 per cent for first year and 2 per cent for each succeeding year.

Remarks: Program has been well received and has not been difficult to enforce. Total of 501 certificates have been issued since 1933.

Wisconsin

Classification of plants: None specified in proposed legislation.

Qualifications of operators: Proposed law sets up three classes based on experience; Class A—five years, Class B—three years and Class C—one year.

Remarks: Proposed legislation failed to pass in 1941.

Experience in Bimonthly Billing

By Franklin W. Roberts

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by Franklin W. Roberts, Commercial Director, Dept. of Water and Power, Los Angeles.

ON July 1, 1943, the Los Angeles Dept. of Water and Power adopted the plan of billing its domestic electric and water accounts once every two months. There was much careful weighing of the arguments for and against this radical departure from the monthly billing policy, which had been in effect since the inception of the department. Many reasons for the change existed. The southern California region was one of the nation's most critical manpower areas because of the war production program. The department's personnel was reduced by the loss to the armed forces of nearly 1,300 trained employees who could not be fully replaced. There was a vital need to conserve critical materials as well as manpower. Paper, gasoline, oil, automobiles and office machinery were all in critical supply. The post office was overburdened, and since the department was the largest user of the mails in the city, the elimination of more than 4,000,000 pieces annually meant a saving in this one item alone of about $64,000 and freed postal employees for the handling of the tremendous increase in mail.

Careful estimates of possible savings were made. Reductions in personnel and materials indicated an estimated saving of $270,000 yearly. Some increase in the write-off to bad debts was anticipated and the possibility of curtailed consumption was considered. As bills for half of the domestic customers would be delayed one month, unbilled revenues would increase and there would be a corresponding reduction of working capital, estimated at $350,000 for water and $500,000 for electricity. But the knottiest problem of all was the effect on public relations. Would the customers accept the plan? There would be an outright saving by the customers of at least $80,000 annually in reduced check cost and postage, as well as an undetermined but substantial saving in transportation expense and time. The customer would be helping to conserve manpower for the war effort, a factor which would grow in importance the longer the nation was at war.

After the decision to adopt bimonthly billing had been made, the first step taken was to tell the story to the customers. The newspapers cooperated splendidly; the large metropolitan dailies, as well as the community papers, were generous in giving publicity to the plan. Each customer received with his last monthly bill a carefully worded notice explaining the change. The following month, when he would normally have received a bill, another such notice was sent. With his first bill covering a two-month period, he again received an appropriate message. This educational program minimized

any temporary inconvenience, pointed out the many advantages and asked for cooperation in meeting the emergency conditions. The response was gratifying and wholehearted.

Success of Plan

The plan has been in operation for more than five years, and the extent of its success, from the standpoint of both customers and the department, can now be determined. In considering the customers' acceptance of the plan, it should be noted that there were about 850,000 active accounts when it was started in July 1943 and 967,111 on June 30, 1948. Customer savings were estimated at approximately $80,000 in 1943; it is now estimated that the annual saving is about $100,000 for a greater number of customers. Many have written giving their opinions, and it is pleasing to say that the majority has approved of the plan, either on the basis of savings in customer time and expense, or in recognition of the reduced operating costs.

One of the best tests of customer acceptance is the history of collections. The courtesy notice (a polite name for a notice sent out on all accounts unpaid fourteen days after mailing the bill) was mailed, in June 1948, on only 21.4 per cent of the accounts (as against 24.7 in 1942), the other 78.6 per cent having voluntarily paid the bill during the first fourteen days. Forty-four days after mailing the original bill, a duplicate of all unpaid accounts was mailed to the remaining 3.5 per cent (3.3 in 1942) of the customers who had not paid their bills. After 52 days all remaining unpaid bills are sent to field representatives, who attempt to educate the customer to adopt more prompt paying habits. In June 1948 these bills represented only 1.9 per cent (1.5 in 1942) of those originally mailed. As the result of this educational program, only 0.09 per cent (0.11 in 1942) of the services were actually shut off for nonpayment of bills. It will be seen that the present excellent payment record compares favorably with the fine record when bills were rendered monthly.

As previously stated, there was some concern over the possible increase in the write-off of uncollectible bills when the bimonthly plan was first considered. The write-off was down to 0.116 per cent of earnings in the fiscal year 1942 and had dropped to 0.07 per cent by June 30, 1943. It was hoped that the wartime economic conditions would counteract the effect that bimonthly billing might have on the size of the uncollectible bills. The write-off actually dropped to 0.036 per cent in 1944 and then to 0.034 in 1945. It rose to 0.04 per cent in 1946, 0.046 in 1947 and nearly 0.05 in 1948. This excellent record is, of course, not a result of bimonthly billing but occurred, possibly, in spite of it. The housing situation has prevented the moving of customers from one location to another to a considerable degree. The large number of gainfully employed customers at increased wages and salaries has tended to increase the number of voluntary payments, and the decrease in final bills has allowed the department to concentrate its collection efforts on that type.

The third factor which caused concern was the possible curtailment in the use of residential water and electricity. In the fiscal year ending June 30, 1943, the last year of monthly billing, the average annual electric consumption for each residential customer was 985 kwhr. of electricity and 17,200 cu.ft. of water. In 1948 the average

annual consumption had risen to 1,484 kwhr. of electricity, a gain of 50.7 per cent, and to 20,600 cu.ft. of water, a gain of 19.8 per cent.

When the plan was adopted, it was estimated that the department would save about $270,000 a year through reductions in personnel, materials and equipment. On January 1, 1943, the department had 709 employees in its commercial division, which was responsible for meter reading, billing, bookkeeping, turning electric services on and off, making investigations and adjustments, collecting, rating credit, accepting orders, giving information, and other miscellaneous commercial activities. These 709 employees handled 841,294 accounts, or an average of 1,187 active accounts per employee. In December 1947, after five years of bimonthly billing experience, 586 employees were handling 946,174 active accounts—an average of 1,615 active accounts per employee. (Throughout the period 1943–47 this figure varied from approximately 1,575 to 1,675.) On a monthly billing basis, 797 employees would be necessary to handle the present number of accounts, or 211 more than are now employed. The savings in the salaries of these 211 employees and the reduced postage, automotive, office machinery, paper and other material costs are conservatively estimated at approximately $750,000 for the past year and at about $3,000,000 over the past five years. The customers during this same period have saved approximately $500,000 in check and postage expenses.

Conclusion

Is it possible for utilities to read meters and render bills every two months and thus accomplish significant economies without arousing unfavorable customer reaction and suffering excessive uncollectible losses? Will a severe depression, or even a slight recession, prove a bimonthly billing plan unworkable? Should the plan be regarded only as a wartime expedient, useful in helping to close ranks after losses in manpower and to conserve equipment not easily replaceable? Most of the companies who adopted the plan, including one with more than 30 years of bimonthly billing experience, support the conclusion that it should be continued. The customers accept the plan as economically sound and pay their bills promptly, and complaints traceable to bimonthly billing are practically nonexistent. The anticipated savings have been more than realized. Enthusiasm for the plan rests upon experience with it; lack of interest seems to be largely a matter of preconceived opinion. As they say about olives, "You've got to eat 'em to like 'em."

Water Quality Control in California

By Frank M. Stead and Edward A. Reinke

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by Frank M. Stead, Chief, Div. of Environmental Sanitation, State Dept. of Public Health, San Francisco, and Edward A. Reinke, Chief, Bureau of San. Eng., State Dept. of Public Health, Berkeley, Calif.

THE subject of water quality control is broad and of great importance. Hence, the authors believe that this discussion should deal not so much with technical details as with a statement of basic principles and their interpretation in terms of the working programs of water and health departments. Since these principles revolve around the factor of responsibility, it is logical to take up first the responsibility of water departments. Any agency supplying a commodity for public ingestion, such as food, milk, ice or water, has an inescapable responsibility to make sure that the commodity is wholesome. This inherent guarantee on the part of the purveyor is entirely independent of any specific statement, written or oral, and is an integral part of the concepts of common law and justice. As a corollary to this principle, health departments as agents of the public have the duty to insure that such responsibility on the part of the purveyor is fulfilled. Even though there were no written law whatsoever on the subject of public water supply, this duty of water and health departments would exist. Written law does not create the responsibility but merely serves the purpose of emphasizing and specifying a method by which it can be carried out.

Included in the responsibility of the purveyor for the wholesomeness of his product are the concepts that a water supply shall be bacteriologically safe, free from injurious chemical substances and suitable for the uses to which it is put. This means that water for domestic use shall be clear, potable and chemically acceptable, and shall not have any objectionable tastes and odors. Uniformity of product is an important but not always recognized requirement.

In addition to the responsibility on the part of the water corporation, each employee has an individual responsibility. A laborer who merely furnishes the muscle to turn a valve under immediate supervision has an extremely limited degree of responsibility, while a technically skilled operator of a treatment plant has a high degree; and varying degrees exist between these extremes.

The responsibility of departments of public health is discharged in either or both of two ways—by continuing though intermittent examination of the results achieved and by an appraisal of the facilities for obtaining them. In other words, health department personnel may merely inspect and test the

water as it reaches the consumer, or they may in addition investigate the adequacy and sanitary safeguards of all aspects of the source, treatment, storage and distribution facilities of the water system.

Historical Summary

Before proceeding to an application of these basic principles to the joint efforts of California water works operators and health departments at the present time and in the immediate future, a very brief review of some of the most pertinent points in past water supply developments in California should be set forth. California, to a greater extent than many other states, has drawn upon ground water sources as a means of supporting extremely rapid development in certain areas. As pointed out by Samuel B. Morris at an Association symposium two years ago, the heavy use of ground waters—even to the point of serious overdraft—is all that enabled agricultural and urban development to reach a point where the huge capital costs of water importation could be supported in southern California. But this hurried and large-scale development of ground waters for agricultural purposes had its detrimental as well as beneficial effects, because irrigation wells have been constructed with little regard to the bacteriological quality of the water. When residential uses replace agricultural, not only are existing wells found to be unsuited to the production of domestic water but frequently entire aquifers have become endangered, if not actually contaminated.

Surface supplies, perforce, supply most of the water needs in California, but scarcity has sometimes made the problems of the production of domestic water from surface supplies well nigh unsolvable. Some areas, it is true, have developed sources of water in places remote from habitation or even on the upper slopes of the Sierra Nevadas, but most of California is dependent either on populated watersheds or on the lower reaches of streams which receive wastes ranging from treated to raw—domestic sewage, organic and inorganic industrial wastes, the return drainage from irrigation and the natural runoff of the extensive areas. Hence, a surface source suitable without treatment is very rare, and some water supplies are approaching nearer and nearer the point of being unsalvageable for domestic use. In juxtaposition to this gloomy trend should be considered the spectacular cleanup program now under way to halt and, at times, actually reverse the tendency toward increasing pollution of the surface waters of the state.

Another type of problem results from the fact that in a large portion of California, including the historical gold country, water development for all uses has been accomplished by a system of open ditches and canals. Sometimes the water from such ditches is diverted to pressure systems serving communities and is, of course, amenable to treatment, but, over extensive areas, the ditches themselves are the distribution lines and many families, schools, camps, resorts and restaurants have no other supply for drinking purposes.

Several types of law exerted their effects on early water quality problems in California. Riparian law, which has had perhaps the most widespread influence, states that each owner of

land is entitled to reasonable use of the water flowing through or past his property but not to unreasonable use or uses that would injure the water for downstream users. Amplifying riparian law were the provisions of the Public Health Act of 1907 which forbade completely such acts of water pollution as bathing or washing of clothes in waters intended for drinking purposes, or permitting livestock to pollute such waters. It was recognized, however, that sewage effluents in inland areas frequently reached streams, and to protect the public health the act provided that the business of sewage treatment and disposal in such areas be carried on under permit from the California Dept. of Public Health. The business of supplying domestic water to the public was dealt with directly in the Sanitary Water Systems Act of 1913, which had two major provisions; it forbade outright supplying to the public any water which was "impure, unwholesome, unpotable, polluted or dangerous to health" and also required that water systems having 200 or more service connections, or supplying a hotel or labor camp, be carried on under permit.

Another document sometimes having an effect similar to law was the standards for certification of waters used on common carriers in interstate travel, adopted in 1914 by the U.S. Treasury Dept. and administered by the U.S. Public Health Service in that department. These standards have had an important effect on concepts of water quality, and it is important to note that they were divided into three parts. Bacteriological standards, which were mandatory in nature, took account of both the degree and the frequency of sewage contamination in appraising a water supply. Chemical standards, which were recommended rather than mandatory, considered not only the health of the consumers but also the comfort and convenience of the traveling public. Lastly, great emphasis was properly placed on the importance of physical conditions surrounding a water system, the sanitary safeguards in construction and the making of sanitary inspections as a means of insuring the continuous delivery of safe water to the consumer. The statutes and standards referred to have been revised, but the concepts on which they are based have not changed through the years.

Quality Control Program

The foregoing points will serve as a background for a statement on the future program for water quality control as seen by a department of public health. The most specific guide to the probable nature of that program is to be found in the amended versions of the statutes previously mentioned as they are now set forth in the Health and Safety Code (Chapter 4, Part 2, Division 5; Chapter 6, Part 3, Division 5; and Chapter 7, Part 1, Division 5). The administration of a law, however, is as important as its text, and, as stated earlier, certain fundamental principles should furnish the real guides in shaping the program.

Consequently, the lion's share of the job of water quality control will continue to fall to water supply organizations themselves. Included in the job are the making of regular inspections of watersheds where surface sources are involved; routine studies and control of algae and other aquatic growths

in open reservoirs; self-policing of the operation of all treatment works (especially those for the purpose of making water bacteriologically safe); maintenance of an adequate water-sampling program; employment of a program of disinfection on new construction and during emergencies such as fires or other disasters; routine flushing and inspection of distribution lines; investigation of consumer complaints; and inspections and follow-up to prevent and eliminate cross connections in the portion of the system for which the water company or department is responsible.

One of these duties requires further emphasis; namely, the maintenance of an adequate sampling program, both chemical and bacteriological. The principle of guarantee of commodity quality by the purveyor requires that the purveyor or producer perform quality control testing. The best single statement of an adequate quality control testing procedure that has been set forth to date, and one that has been formally accepted by the water works profession, is the 1946 revision of the U.S. Public Health Service Drinking Water Standards. The authors believe that the maintenance of a field and laboratory inspection and testing program sufficient to demonstrate conformity to these standards is an obvious responsibility of every public water company or department. Field inspection should be done by qualified men, whether employed or retained on a consulting basis, and laboratory work should be performed in a certified laboratory in accordance with *Standard Methods*. Records of such tests and inspections should of course be available to the departments of public health having jurisdiction.

Local departments of health have an important role to perform in the field of water quality control. Except where permits are required under the Pure Water Law, they have the principal responsibility of ascertaining that water served to the public is pure, wholesome, potable, unpolluted and safe, and of advising and assisting water companies and departments in achieving this result. Local health departments also make inspections and collect samples, which may supplement, but do not take the place of, those of the water purveyor. The local health department is in the key position to carry on a program for the elimination of cross connections within consumers' premises, especially public buildings, commercial establishments and industries. Local health departments logically perform services of these types even in the case of companies which are operating under permit.

Administration of Permit System

The role of the California Dept. of Public Health in the field of water quality control is important but should not be emphasized so strongly as to lose sight of the parts played by the supplier of water and the local health department. Briefly, the state health department's job is to administer the permit system in a constructive and reasonable manner and to carry on those correlated activities which can be done most effectively by a single agency operating throughout the state. The department believes that the permit system, while primarily intended to protect the water consumers, can be of powerful assistance to water suppliers in California, and in closing the authors would like to indicate a few of

the concepts proposed as a guide in the administration of the permit system:

1. The permit investigation will be primarily a functional study, sufficiently extensive to ascertain that the water system is designed, constructed and operated to protect fully the health and interest of the consumer. It will not be so detailed as to duplicate the designing engineer's efforts.

2. Priority of attention will be directed to those water systems having the greatest potential hazard to public health. Applications for permit voluntarily submitted will be processed. The enforcement program, however, will be directed toward those water systems most likely to be the means of transmitting disease or chemical poisoning, or those involving some other important and urgent aspect of public concern.

3. Water works groups will be given the greatest possible latitude in policing themselves and determining their own destiny. The present statute includes a provision that the standards of the California Section, A.W.W.A., shall be acceptable for distribution system enlargements. This reflects a meeting of minds on the part of the legislature, the California Dept. of Public Health and the water works men in California.

4. The U.S. Public Health Service standards already discussed will be used as a guide in appraising the program of any public water company or department applying for a permit. The standards as a whole, and not merely the number of bacteriological samples to be collected monthly, must be kept in mind. Great importance is attached to the type of field investigation made at the time of collection of routine samples and to the follow-up of bad samples.

5. The training of operators of water works systems and water treatment plants is a matter of great importance and should be encouraged. Although no definite program along this line has been developed by the department, it is without question overdue.

Discussion

Bernard Schiller

San. Engr., Southern California Water Co., Los Angeles.

The paper presented by Stead and Reinke is of particular importance to the writer as sanitary engineer for the Southern California Water Co. Their warning that the California Dept. of Public Health is going to enforce the Sanitary Water Systems Act of 1913, amended and revised in 1947 and now known as the Pure Water Law, is good news to any responsible operator of a water works system in the state of California.

The writer was recently called upon to investigate a case of typhoid fever contracted by a person whose home was served by the Southern California Water Co. Upon investigation it was learned that the house in question had two water sources: a high-pressure domestic service from the Southern California Water Co. and a low-pressure irrigation service from a small irrigation company. Although it was never determined that either water service was directly responsible for the typhoid fever, obviously the water supply in the home was the first to be suspected.

Forty homes in the area were found to have two supplies, and two definite cross connections were located. Several homes had irrigation water as the single source for all purposes, which at best could only be considered as a questionable domestic supply. Before the investigation was completed, a second irrigation supply was involved and two additional cross connections were found. One property owner had connected a small gear pump to the irrigation supply in order to irrigate a sizable lawn inexpensively. The plumbing in his home was connected to the high-pressure system. If the irrigation line had been cross-connected with the plumbing in the house, a serious tragedy might have occurred had the irrigation water been the carrier. Numerous instances of this type could be averted by an aggressive enforcement of the Pure Water Law.

The authors have made very clear the position of the state and local health departments and the water works operators. The state health department is going to review and process the permits which are required under the law. The local health departments will be the enforcement agencies, continually checking and sampling the systems. The water supply organizations will be responsible for the quality of the water they are serving.

Every water works official will agree with the authors that "Any agency supplying a commodity for public ingestion . . . has an inescapable responsibility to make sure that the commodity is wholesome." It is not necessary to go very far back in history to learn of the havoc that a waterborne epidemic can cause. Although it may not always be possible to supply a perfectly clear water or one that is entirely free from objectionable tastes and odors, water suppliers are constantly striving for this goal.

The Sanitary Water Systems Act, passed in 1913, has not been enforced simply because it was impossible to do so. Permits were required for every change, addition or modification to the distribution system, source of supply and treatment works. With the thousands of water systems in this state, a tremendous force would have been required just to process the permit applications, let alone the possible field investigations. The amended version of the law includes a provision that "standards" of the California Section shall be acceptable for distribution system enlargements, eliminating an untold number of permits. The "Standards of Minimum Requirements for Safe Practice in the Production and Delivery of Water for Domestic Use" (1) which have been adopted by this Section and which, it is hoped, will be approved by the 1949 legislature, will eliminate countless other permits for alterations in the source and treatment facilities of the water companies in the state.

The California Dept. of Public Health is to be complimented for taking the initiative in enforcing the Pure Water Law. The principles which the authors have set forth in their paper are certainly broad enough so that any water department should be ready, willing and able to comply with the law. Water works operators owe that responsibility to the communities they serve.

Reference

1. California Water Supply Standards. Jour. A.W.W.A., **41**:1 (Jan. 1949).

Carl Wilson

Consultant, Water Quality and Treatment, Los Angeles.

The authors have very properly stressed the responsibility of water works officials for the safety and acceptability of their product for human consumption. In the event of a waterborne epidemic, it is those officials, and not the health officers, who would be penalized if they were shown to have been criminally negligent. This has been proved in a number of instances—at least once in California—and most water works men are keenly aware of their responsibilities. Many of them exceed the minimal requirements laid down in the 1946 revision of the U.S. Public Health Service Drinking Water Standards, taking more samples, making more field inspections and carefully plotting sampling points so that they will best reveal any weak spots in the lines of defense. On the other hand, a few officials seem supremely optimistic and make little effort to fulfill their obligations.

The writer knows of one municipality which regularly pays for laboratory control but which has not taken a single sample, either bacterial or chemical, in months. Fortunately, nothing has so far gone wrong. All its water is derived from deep wells which in the past have been free from bacterial contamination but which are in the path of heavy industrial wastes that may any day invade them, as has already occurred in nearby wells. One or two publicly owned supplies which are supposed to be chlorinated cannot be induced to keep records of their chlorine dosage. Freedom from trouble in the past seems to have induced a lethargy toward the present and future which it is difficult to overcome. A timely admonition from state or local health officials would help in obtaining better control, and the paper under discussion should produce a salutary effect upon all those who read it.

The authors outline the functions of state and local health departments in the control of water quality. These functions overlap those of the water purveyor, but the writer believes that the conscientious water works official welcomes the efforts of such bodies as a useful adjunct to his own. An army encampment which relied upon one sentinel, however careful and observant he might be, would be inadequately guarded, and three checks upon the quality of water must certainly afford greater safety than would only one. More than that, the effect upon the psychology of water consumers is always favorable when they are told of the threefold protection.

Importance of Field Inspection

The paper under discussion also accentuates the importance of the sanitary field inspection, a point which will meet with almost universal approbation. It seems that in practice the results of the field inspection are often given more weight than is accorded to laboratory findings, sometimes ill advisedly. On one occasion, when laboratory results showed coliform bacteria in a reservoir where they had never previously occurred, an immediate field examination brought forth these facts: The reservoir was well roofed and screened, the roof being of the hip and trough type with the screened open ends of the hips facing on the dam. An adequate diversion ditch had been

provided all around to divert surface runoff to the sewer. The reservoir was filled through a bricklined tunnel conveying only ground water which had never been coliform positive. At the time, a construction crew for a private contractor was engaged in cutting a new street across the downward slope of the dam, and he had erected a small temporary corral near the top, in which four mules were found at the time of the inspection. The usual collection of litter and feces covered the ground, and it seemed apparent that the reservoir contamination had been due to the prevailing up-canyon winds, which had blown over the corral and into the open ends of the roof. No other suspicious condition could be found, and the contractor was asked to remove the animals and clean up the area, which he did immediately.

Samples taken the next day were still positive, but, since not all of the reservoir water had been replaced, no anxiety was felt. The following day a sanitary sewer from an up-canyon residential area which paralleled the reservoir only a few feet beyond the diversion ditch failed, having been plugged with tree roots, and raw sewage appeared on the surface of the ground, but above the upper end of the reservoir. As soon as this became known, a reserve chlorinator was erected at the reservoir inlet and the water was heavily chlorinated. Further investigation disclosed that the sewage had been leaking underground before it was seen on the surface and had found an easy path through old and defective mortar in the brick lining of the tunnel. The field inspection seemed to prove the bacterial findings correct as far as they went but misleading in significance, for, although the source of abundant pollution was disclosed, it was all of nonspecific origin. The sanitary inspection was given the greater weight, fortunately without disastrous consequences. The moral which might be deduced from this experience is: "Chlorinate whenever bacterial findings are positive, and make the field inspection while covered by this first line of defense."

The paper is an excellent and timely one. In these days of uncertainty and threatening war, with talk of sabotage on every side (seemingly it is not always mere talk), no water works official can afford to relax his control or to neglect even minor details in his records. This paper will spur the water industry to greater effort in the discharge of its far-reaching responsibilities.

This Month's Cover

The gentleman in the new-look bathing suit is preparing to engage in some submersive activity on the Lake Huron intake (*see* p. 141) for the Saginaw-Midland project. Sharp-eyed readers who spot the can of "Six Oclock" peaches will have to decide for themselves whether this is standard diving equipment.

Saginaw-Midland Water Supply Project

By Louis R. Howson and Vernon R. Kneer

A modified version of a paper presented on Sept. 18, 1948, at the Michigan Section Meeting, Bay City, Mich., by Louis R. Howson, Partner, and Vernon R. Kneer, Engr., Alvord, Burdick & Howson, Chicago.

THE Saginaw-Midland, Mich., water supply project is an illustration of coordination of effort between communities for the common good which might well serve as an example to others. As measured by the population served, it is a large project, involving a capital outlay exceeding $10,000,000, which is considerably more than the total expenditures by both communities for their entire water systems to date. The unique features of this coordination of effort are evidenced by the fact that it was necessary for the Michigan state legislature to pass enabling legislation before the work could go forward.

Inception of Project

Although Saginaw and Midland are located on rivers having considerable volumes of flow, the matter of water supply has long been under discussion. The quality of the river supply, as measured by tastes and odors increasingly difficult to control, high chlorides and hardness, has been deteriorating over the years. Even though treated with the most modern of purification facilities expertly operated, the quality of the water delivered to the mains has not been satisfactory. It became increasingly evident that ultimately Saginaw Bay or Lake Huron must be developed as the water supply for these communities.

A local water committee, whose membership was made up of city officials and outstanding citizens of the two communities, was organized to study the water supply requirements and outline a procedure. The committee recommended a basic plan which was adopted by both cities. It provided for the abandonment of the present river sources of supply and the development of a supply from Lake Huron, drawn from the vicinity of Whitestone Point, approximately 50 miles north of Bay City and 65 miles from Saginaw and Midland. The committee also decided upon a basic capacity of 43 mgd., split between the two communities—23 mgd. to Saginaw and 20 mgd. to Midland. These allowances provide for a 100 per cent growth in the domestic uses of water at both Saginaw and Midland, with the Midland proportion making available 12–15 mgd. to the Dow Chemical Co. Although this represents but a very small part of the total water used by that company, the revenue guaranteed to the city of Midland was essential to the practical financing of the project.

At this stage of the proceedings, engineers were employed to develop the details of the project, which included the determination of the intake location, type and size; the water depth; the location, routing, size and

pressure of pipelines; economical pumping heads; and similar basic matters.

Intake Location

The location of the intake had been tentatively selected by the water committee as in the vicinity of Whitestone Point. This appeared to be the most southerly location where preliminary studies of the committee indicated that a good water supply could be assured at all times.

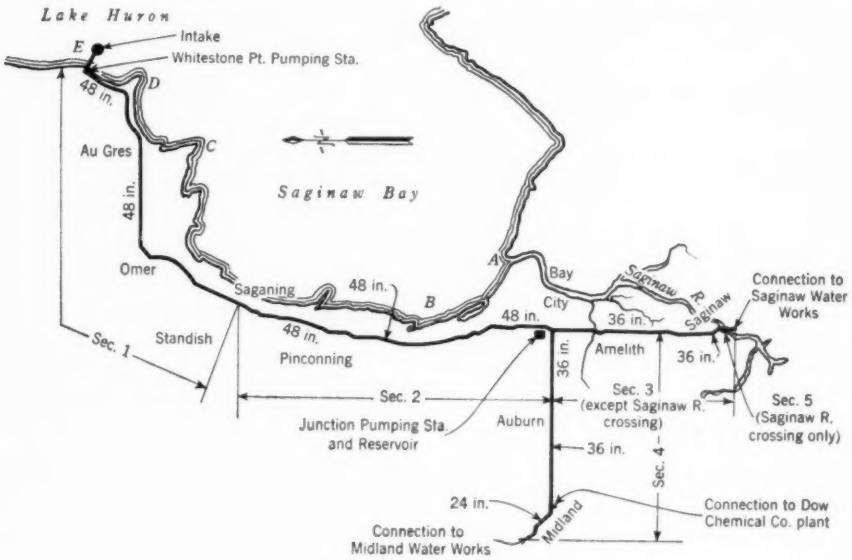

FIG. 1. Plan of Project

From January 1935 to May 1937 the Michigan Stream Control Commission had carried on an exhaustive study of the pollution of Saginaw Bay with particular reference to the concentration of chlorides. In general, this survey (sampling points are indicated by the letters *A–E* in Fig. 1) showed that objectionable chloride concentrations were found at some time in practically all parts of Saginaw Bay south of Lookout Point, and that the nearer one approached the mouth of the Saginaw River, the higher the concentrations and the greater the proportion of the time in which they would be prevalent. It was further found that after Lookout Point was passed concentrations decreased rapidly to the north. Improvement both in average and maximum concentrations was apparent as far north as Whitestone Point, above which little if any improvement was disclosed. This survey was a real contribution in ascertaining and making available the facts on the pollution of Saginaw Bay, from which it was concluded that the farthest southerly location for the intake should be at Whitestone Point.

Another essential of an intake on the Great Lakes is a depth sufficient to insure, insofar as practicable, against trouble from frazil ice. This formation is rarely encountered in water exceeding 40 ft. in depth but is

a common occurrence in water 35 ft. deep or less. A study of the U.S. Corps of Engineers lake survey maps, substantiated by more detailed surveys, disclosed that it was practicable to reach a 50-ft. water depth east of Whitestone Point 2 miles from shore, and that this depth of water did not extend much south of Whitestone Point. It was accordingly recommended that Whitestone Point be officially adopted as the location for the intake.

Project Plan

An analysis was made of the variations in water demand at Saginaw, where good records of daily and peak hourly rates were available over a considerable period. It was found that the peak day of the year was approximately 165 per cent of the average day, that the peak month was 28 per cent above the average day and the peak week 50 per cent above the average day. These percentages correspond, in general, with the experience in most midwestern cities containing a normal proportion of industry and residential use.

As a basis for design capacities, peak rates govern, whereas the economic considerations are more largely determined by average uses and the revenues therefrom.

The project design provides for an average use of 43 mgd. and a peak day of 71 mgd. All hourly rates above the 24-hour average on the maximum day will be taken care of in the individual water plants.

The project plan, shown in Fig. 1, consists essentially of a 2-mile-long, 66-in.-diameter steel intake, a 70-mgd. electric pumping station at Whitestone Point, 48 miles of 48-in. prestressed reinforced concrete pipe from the Whitestone Point pumping station to the Junction pumping station, a 70-mgd. pumping station, a 5-mil.gal. reservoir at Junction and two 36-in. prestressed reinforced concrete pipelines. Each line is approximately 15 miles long, one leading to the Saginaw water works and the other to the Dow Chemical Co. and the Midland water works.

Intake and Crib

Because intakes are costly structures, the provision of additional capacity in the initial construction is much less expensive than the building of duplicate facilities at a later date. It was therefore decided to base the

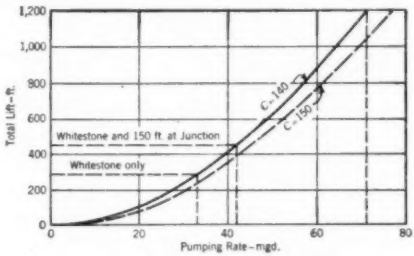

FIG. 2. Total Lift for Various Pumping Rates

design of the intake upon its ability to deliver 100 mgd. to the suction well at periods of low water level in Lake Huron. The intake will deliver 100 mgd. at low lake level even though the Hazen-Williams *C* falls to 110. As the intake has a bituminous enamel lining, no such deterioration in capacity is expected.

The most important consideration, other than the water depth, in securing freedom from frazil ice on the Great Lakes, has been that of low port velocities at the intake structure. The intake for this project consists of an octagonal timber structure approximately 60 ft. across with ports designed to admit 100 mgd. at velocities

of 3 ips. The structure is built of 12 × 12-in. timbers, drift-bolted and bolted together, weighted with concrete and crushed stone, and firmly bedded on a crushed-rock mat on the bottom of the lake.

The 66-in. intake terminates in a bell-mouthed special opening inside the intake structure. The intake itself consists of 66-in. steel pipe laid in a trench with a minimum depth of 10 ft. After the trench had been backfilled to the original lake bed, the pipe was covered with 1 cu.yd. of broken stone per lineal foot of trench, for protection against wave wash or scour.

The intake pipe in normal trench depth has a $\frac{5}{8}$-in. shell thickness. Pipes were shipped to the assembly yard at Tawas in 40-ft. lengths, which were coated with spun bituminous enamel lining on the inside and outside. Three of the lengths were welded together and the resulting 120-ft. sections were then fitted with watertight bulkheads, rolled into the water and towed to the site about 15 miles from Tawas.

At the ends of each 120-ft. length, on the horizontal diameter, there are heavy shackle bolt connections to hold adjoining sections together. The sections are also jointed by a Dresser coupling. Both the Dresser coupling and the shackle bolts were drawn up by a diver underwater.

Approximately 25 per cent of the trench at the shore end is in hard but stratified rock, which was excavated to a maximum depth of approximately 20 ft.

At the end near the intake, the contractor used land equipment for about 1,100 ft. He built a double breakwater out into the lake about 500 ft. and excavated this section as open-trench land work, blasting the rock. Beyond 1,100 ft. from the suction well, marine equipment was employed. The dredge, which operated with a 12-cu. yd. bucket, was said to be the most powerful on the Great Lakes, and removed the heavy rock without blasting.

All pipe was coated during the summer and fall of 1947 and all but 1,200 of the 10,400 ft. of pipe was laid in 1947. The coating materials and procedure were in accordance with A.W.W.A. Standard Specifications 7A.5.

During the winter the 1,200 ft. of pipe not yet laid remained exposed and was subjected to temperatures as low as minus 28°F. The lining cracked and peeled away quite generally and the coating was also damaged, but less seriously. Before adopting a repair procedure, it was decided to remove for inspection the last 120 ft. laid in December 1947. This pipe was in 40 ft. of water, which probably reached a minimum temperature of about 34°F. The lining and coating were in perfect condition, demonstrating the fitness of the material for the service and showing that the failure of the pipe aboveground was the result of the extreme cold. All loose matter was removed from the pipe, which was then primed and coated by hand using the same materials as on the original machine-spun coating job.

Pipeline Design

The economics of the pipeline and pumping stations were considered jointly. The pipeline head results almost entirely from frictional resistance to flow. The greatest difference of elevation over the 48 miles of the 48-in. line does not exceed 30 ft. and, over the entire 80 miles of pipelines, does not exceed 80 ft.

Comparative studies were made to determine the economical diameters, the heads for which the shells should

be designed and the heads pumped against. It is obvious that the smaller the pipeline the greater the head will be, and that the most economical line will be the one delivering the required amount of water at the least annual cost. The comparative studies therefore included the fixed charges on the capital investment for various diameters and strengths of pipe, and the pumping facilities involved, plus the power consumed in operating the pumping equipment against the friction heads computed under various conditions.

Analyses of this kind led to the conclusion that: [1] the main-line pipe between the Whitestone Point and Junction pumping stations should be 48 in. in diameter; [2] the pipeline should be designed for a 300-ft. head throughout; and [3] the branch lines to Saginaw and Midland should be 36 in. in diameter and designed for a 300-ft. head. It was also considered desirable to have some storage at the Junction pumping station, and for that purpose a 5-mgd. reinforced-concrete reservoir is provided.

Pumping Installations

At the time of design there was no adequate power connection within several miles of the Whitestone Point pumping station. A comparison was accordingly made of the economics of diesel engine pumping and electric power purchased from the Consumers Power Co. high line located some miles away. Detailed studies of the comparative costs under the two systems resulted in the adoption of electric pumping at a power rate which will average slightly less than 1¢ per kilowatt-hour at the present time and will be reduced to approximately ¾¢ when the pumpage increases to the design capacity of the project.

Figure 2 shows the total pumping head required to overcome friction, assuming C in the Hazen-Williams formula equals 140 and 150, and with rates of pumping up to the maximum day rate (approximately 71 mgd.) at a time when the average day rate is 43 mgd. It will be noted that the total head for a peak of 71 mgd. will be approximately 1,200 ft., which would require the construction and operation of four pumping stations, each of 300-ft. head.

Initially, the plant started operations with an average pumpage of between 20 and 25 mgd., and the total head was less than 150 ft. for pumpage rates of less than 25 mgd. During most of the year the pumpage initially will be less than the 300-ft. pumping head available from the Whitestone Point installation. At all such times the Junction station will be idle.

The present installation consists of four units at the Whitestone Point pumping station, three of 20 mgd. each and one of 10 mgd. The capacities thus chosen will insure operation, with properly selected pump characteristics, at a rate of maximum efficiency under all conditions. Each of the four units consists of two pumps in series. If the pumpage is less than 18 mgd., only one of the two pumps in series will be operated to force the water from Whitestone Point through to Saginaw and Midland. Between 18 and 33 mgd., the second pump in the series will be operated. The total head will then be 300 ft. or less, as determined by the use, and the water will flow through to Saginaw and Midland without the operation of the Junction station until a rate of use of 33 mgd. is reached.

When the use exceeds 33 mgd., the Junction pumping station units will be put into operation, increasing the

delivery of the 300-ft. Whitestone pumps to 42 mgd. because the pipeline is shortened back to Junction. The Junction station pumps, with a 150-ft. head, will be able to deliver 42 mgd., divided between Saginaw and Midland in the ratio of 23:20. The piping is so arranged that when Junction is not required to operate, the water will flow straight through to Saginaw and Midland.

Inflow to the 5-mil.gal. reservoir is through automatically controlled cone valves which will prevent overflow. When the Junction station is in operation, the pumps may draw either from the reservoir or from the 48-in. line, as desired.

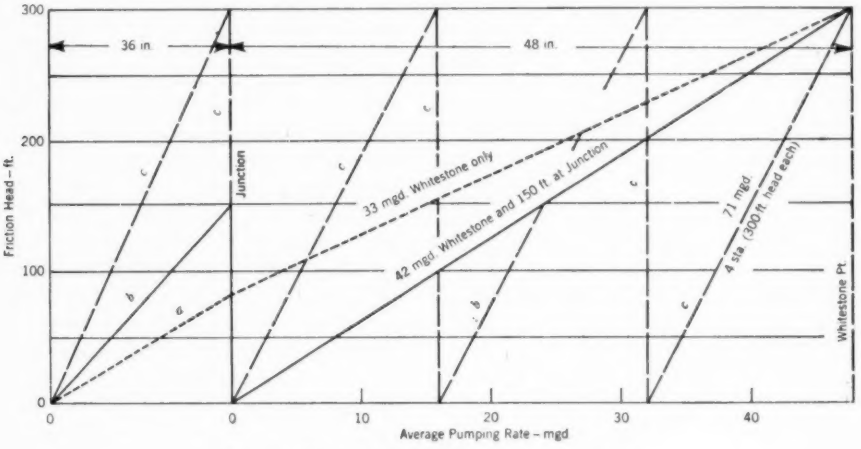

FIG. 3. Hydraulic Profiles for 1–4 Stations

At a later date pumping stations, for which outlet connections are now being installed in the line, can be provided intermediately between Whitestone Point and Junction. The inclusion of one station will divide the pipe length in half and increase its capacity by approximately 40 per cent. The installation of two stations and the adding of a second pump to each of the presently installed Junction pumps to make two units in series will increase the ultimate capacity to 71 mgd. The hydraulic profiles with one to four stations in operation are shown in Fig. 3.

The decision on the ultimate number of stations is reserved until it is learned how much Saginaw and Midland may each find it practicable to reduce their peak day demands. For illustration, Saginaw has available Lake Linden, a suction storage reservoir with a 50-mil.gal. capacity, now used when the river water is bad. If this reservoir is kept filled during periods of ordinary requirements and used during peak periods, it would be possible to reduce Saginaw's maximum rate of draft from that of the maximum day to that of the average day in the maximum month, or cut the excess of the peak rate above the average by approximately one half—that is, from 164 to 128 per cent of the yearly average day.

The effect of such a reduction in peak rates upon the number of pumping stations required is shown graphically in Fig. 4 (which is based on a

48-in. main line, 36-in. branches and a *C* of 140). For instance, the single Whitestone Point pumping station operating at a 300-ft. head could deliver 33 mgd. any day, but if the ratio of the maximum day to the average day is 164 per cent, as reflected by the recent Saginaw statistics, the safe design for that one station would be but 20 mgd. Similarly, if the ratio could be held down to not more than 130 per cent, a 300-ft. station at Whitestone Point and a 150-ft. station at Junction would suffice for the average day of 33 mgd.

Protective Features

All excavated areas are coated with a 1-in. skin of concrete as soon as dug. This gives a firm, uniform footing and a clean working surface and insures the accurate placing of reinforcing steel. In addition, at the Whitestone station an asphaltic membrane is built into the pit walls and floors for waterproofing.

All pumps have automatic cone valves on the discharge lines and cone valve main-line controls outside of the stations. Surge relief valves, of the quick-opening, spring-operated angle type, are also provided for use during power failures, line breaks or other emergencies.

At the Whitestone station, where the pumps and motors are below the outside grade, a float cutout switch on the incoming power line stops all pumps and closes the cone valves if any water accumulates on the pump-room floor.

Pipelines are all laid to grade, drained to blowoffs and air-vented at the summits.

Junction Station Reservoir

The Junction station reservoir is of the monolithic box type with flat-slab roof and floor. Its walls are designed as vertical beams held top and bottom, there are no expansion joints and reinforcing amounts to approximately 180 lb. per cubic yard. The entire structure will be protected against temperature stresses by earth berms and covering.

Chlorination

The water will be chlorinated at Whitestone Point and, when necessary to maintain residuals through to Midland and Saginaw, it will be chlorinated again at Junction station.

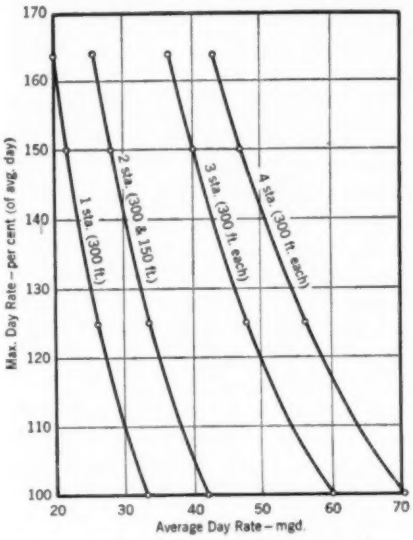

FIG. 4. Effect of Peak Rate Reduction

Costs and Financing

The entire work was subdivided into 25 contracts, the costs of the construction work being estimated at $9,690,400 in October 1945. Bids were asked and received on August 13, 1946. At that time contracts were awarded on all items except the intake and the Whitestone Point and Junction pumping stations. Bids were re-

jected on these three contracts and readvertised for September 9, 1946. The request for bids was amended to permit bidding on a fixed-sum or cost-plus-sliding-fee basis. When the new bids were received on September 9, all three contracts were awarded on a fixed-sum basis.

The total of all contract awards was $10,299,118, a figure only 6 per cent above the estimate made a year earlier. Of the project cost, 98 per cent was on a firm-price basis. Escalator clauses, generally with a 15 per cent ceiling, applied to but 2 per cent of the total cost.

The project is financed through the sale of water revenue bonds by the cities of Saginaw and Midland individually. Saginaw, which had approximately $1,500,000 cash in its water works fund, sold $4,800,000 worth of bonds and Midland $6,000,000 worth.

The Midland issue was a very large one for the size of the community, a factor which was offset in large measure by the execution of a contract between the Dow Chemical Co. and the city guaranteeing that the company would consume a minimum of 7 mgd. over the year, with the privilege of taking up to approximately twice that amount.

The bonds were sold during the second week in September 1946—following the stock market crash—on a 1.85 per cent basis for Saginaw and a 2.23 per cent basis for Midland, both attractive figures, particularly in view of the uncertainty in financial circles at that time.

Construction Progress

As the contracts were let in the fall of 1946, it was expected that no real construction would be undertaken prior to the opening of the construction season in 1947. During the winter the contractors assembled materials and equipment and the work was started. Before pipe laying was begun, 30,000 ft. of 48-in. pipe had been manufactured.

Good progress was made during 1947. The manufacture of pipe was completed and about 60 miles of the 80-mile total was laid; the intake line was 90 per cent laid and the pumping stations were well along. On October 23, 1948, the new system started continuous operation. Aside from a few minor details, the construction was completed.

The final cost, including all escalators, was $10,309,747.81, just $10,000 or 0.1 per cent above the total of the original bids before escalators. This is believed to be a phenomenal record, especially under present conditions.

Organization

The Saginaw-Midland Water Committee still functions. As a permanent operating organization, a six-man board has been set up, with three members from each city, under the chairmanship of Eric Wieneke, the dynamic chairman of the Water Committee. The board has very wisely selected as its manager Alfred E. Eckert, former Director of Public Works of Saginaw, Secretary of the Water Committee and a leader in the project. Vernon R. Kneer is representing Alvord, Burdick & Howson, the project engineers, as resident engineer in charge of construction.

Saginaw and Midland are to be congratulated upon their choice of representatives, their willingness to discuss problems frankly in a spirit of give and take and their efforts to work out so constructively a project essential to the common good.

Significance of Nitrates in Water Supplies

By F. Holman Waring

A paper presented on Oct. 7, 1948, at the Ohio Section Meeting, Mansfield, Ohio, by F. Holman Waring, Chief Engr., State Dept. of Health, Columbus, Ohio.

IN 1945–46 a number of articles by H. H. Comly (1) and other writers (2–4) called attention to the relation between the presence of nitrate in drinking water and the incidence of methemoglobinemia in infants ("blue babies") up to six months of age. This infant ailment developed acutely with marked cyanosis when the nitrate nitrogen content of drinking water and water used to make up milk feeding formulas reached a figure of 10–20 ppm. or more. Some of the cases studied in which severe cyanosis developed indicated the nitrate nitrogen content of the water to be over 100 ppm.

The presence of nitrates in the human body ordinarily results in a breakdown of the compounds to nitrite and ammonia. Apparently young infants are not able to transform all of the nitrite, resulting in the production of methemoglobin in the blood stream, which is unable to carry oxygen. Cures were effected for the infants found suffering from this ailment by changing the water to one of little or no nitrate content; in some extreme cases it was found necessary to administer methylene blue by injection.

In the early studies in Iowa it was found that the city water supply serving the hospital where Comly's observations were first made was practically free from nitrate nitrogen but that the rural water supplies for the homes of the people whose babies were affected contained amounts ranging from 10–20 to over 100 ppm. Subsequently, careful checking of the municipal water supplies in Iowa, and later in Illinois and Minnesota, brought out the point that high nitrate contents were not to be found in municipal waters but were prevalent in many rural supplies.

Ohio Municipal Supplies

Beginning in July 1947, the Ohio Dept. of Health began systematically checking the nitrate content of the municipal water supplies. To date there have been found only ten city water supplies and only 34 village supplies that show an amount of nitrate nitrogen in excess of 1 ppm. There are 456 separate municipal water supplies in Ohio. The 44 supplies found to contain more than 1 ppm. nitrate nitrogen are therefore less than 10 per cent of the total. It is pertinent to observe further that only five municipal water supplies showed over 3 ppm., with none of them approaching the apparently significant amount of 10 ppm. mentioned in the early reports from Iowa. In the light of present-day knowledge, it appears that the amount of nitrate nitrogen which may be deemed minimum or critical in the causing of methemoglobinemia seems to be in the vicinity of 20 ppm.

In late February and early March 1948 Philip J. O'Connor, superintend-

ent of the Warren, Ohio, filtration plant, reported to the department his inability to obtain ammonia-free distilled water from city tap water. At that time none of the knowledge concerning the significance of a high nitrogen content had been disseminated by the department. Accordingly, it was deemed advisable to make an immediate investigation of the incident reported from Warren, to find out if the difficulties in obtaining ammonia-free distilled water were associated with a high nitrate nitrogen content of the Mahoning River water used at Warren. Investigators from the Ohio Dept. of Health conferred with O'Connor, acquainting him with the possible significance of this factor. The first few samples of Mahoning River water examined indicated nitrate nitrogen approaching 10 ppm. Naturally, this caused much concern and a study was at once made to determine the possible reasons for this condition in the Mahoning River water at Warren, since some surface waters used by other municipalities already examined indicated amounts between 1 and 2 ppm.

It was found that the Portage Arsenal at Ravenna had resumed the manufacture of ammonium nitrate, which during the war was used for T.N.T. but was now employed in a highly concentrated fertilizer ingredient. The nitrate dust apparently escaped in the production and sacking operation to such a degree that it was necessary to hose down the interior of the plant one or more times daily, as the accumulation of nitrate dust constituted a serious industrial explosive hazard. Through the cooperation of the U.S. Public Health Service and the military authorities, better housekeeping methods were instituted in the manufacturing process, and the equalizing of the flow through ponding was begun. Gradually the amount of nitrate nitrogen in Mahoning River water downstream from Ravenna has been reduced until at present it averages approximately 2–3 ppm. There were times, however, when the nitrate nitrogen content went considerably above 10 ppm. on composite and catch samples, notably in the latter part of July 1948, when an unauthorized release of lagooned nitrate wastes took place. In the early stages of the investigation of the Mahoning River it was found that Eagle Creek, conveying the effluent from the arsenal, had several hundred parts per million of nitrate nitrogen. In general, success has attended the effort to control the nitrate content of the waters escaping from the arsenal. The release of any lagooned waters will not be permitted except in high stages of river flow, when dilution will serve to hold the nitrate content to a reasonable amount.

The experience at Warren has served to alert the department to the possible hazards from industrial wastes which can impart dangerously high nitrate contents to waters used as drinking supplies.

Ohio Rural Supplies

Following the lead of Illinois, Minnesota and Iowa in studying the nitrate content of rural water supplies, a systematic examination of all such samples sent into the department was begun about the middle of April 1948. It has been common practice for the health commissioners and sanitarians in the state to send in routine water samples wherever a water supply was under suspicion from a bacteriological standpoint. One of the first endeavors, therefore, was to develop a simple

method of screening in the department laboratory, so that the water samples could be set aside for careful analysis if the preliminary test indicated a suspiciously high nitrate content. M. L. Riehl, Chief Chemist, Ohio Dept. of Health, developed a screening test for nitrate nitrogen determination in small amounts of water samples, and his description of the procedure is appended to this paper.

The screening of approximately 10,500 water samples in the five months since the study began has brought out some interesting facts. Five per cent of the rural water samples have seemed to indicate in excess of at least 10 ppm. nitrate nitrogen; 2½ per cent show a content of 10–20 ppm.; 1½ per cent, 20–50 ppm.; and the remaining 1 per cent, over 50 ppm. Several samples have been found to contain over 100 ppm., the largest content noted to date being 190 ppm. It is also noteworthy that 81 per cent of the samples showing the high nitrate nitrogen content of 10 ppm. and over also registered positive bacteriological results.

Current studies in Illinois, Minnesota and Iowa seem to show that by far the largest portion of waters with a high nitrate content is from dug wells. Knowing that dug wells also represent a high percentage of positive bacteriological findings, it would appear that the same situation might prevail in Ohio. In the absence of complete sanitary survey data on the wells, this point is apparently borne out by the fact that not one of the nearly 400 state highway park wells, which are carefully located and drilled, showed a nitrate nitrogen content above 1 ppm.

Sanitary Survey

Beginning in the middle of August 1948, the district engineers of the health department have been furnished with descriptions of ownership and location of the rural wells found to test high in nitrate nitrogen. They have been asked to conduct a sanitary survey of the wells and report their findings, so that the department may in turn try to discover some of the reasons why the rural wells should be showing unduly large amounts of nitrate.

The department is desirous of finding out if the dug well is responsible and whether the drilled well is exempt from the occurrence of a high nitrate content, or, if not, what the causative factors are.

As yet only guesses have been made about the origin of nitrates in rural well water. Among the possible sources may be mentioned organic pollution; mineral characteristics; fertilizer, both natural and commercial; and nitrate-producing plants and organisms in the soil.

Because high nitrate incidence seems to be greatest in dug wells, it appears that the source of the nitrogen must be of surface origin. Preliminary conclusions point strongly to plant life as the chief source, particularly clover and legumes. The practical remedy for the farmer is the construction of a properly located and developed drilled well.

Summary

Drinking waters containing high nitrate nitrogen—10–20 ppm. or more—appear to be the cause of methemoglobinemia in infants, particularly when they are given the water as part

of a modified milk formula. The distribution of such waters appears to be confined mostly to rural wells in which a surface influence may be felt, particularly dug wells. A simple remedy seems to be the abandonment of the affected well and the construction of a properly located and developed drilled well.

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APPENDIX

Screening Test for Nitrate Nitrogen Determination

The samples on which the screening tests are to be made comprise routinely the amounts left over from the bacteriological specimens ordinarily sent in to the health department by the local health commissioners, and represent private and semipublic water supplies in the rural areas. Two-ounce bottles are used for this purpose, hence the need for a screening test employing a small amount of the water sample.

This screening test for nitrates is adapted from "Qualitative Analysis by Spot Tests" by Fritz Feigl. The test depends on the oxidation of the colorless diphenyl amine to form a blue dye in the presence of nitrates and in an acid medium. The original method in the reference is too sensitive for this purpose, and it is necessary to dilute the sample in order to make the break at the desired point.

The reagents used are: [1] diphenyl amine—0.1 g. of the reagent (Eastman No. 105) dissolved in 1 l. of concentrated H_2SO_4 (of reagent quality or of the special "low-in-nitrogen" grade); this reagent is quite stable; and [2] distilled water, nitrate free.

The following procedure is used: [1] place one drop of the sample on a white glazed spot plate; [2] add one drop of distilled water; [3] add eight drops of diphenyl amine reagent; [4] note the rate and depth of the formation of blue color. If the nitrate nitrogen is 10 ppm. or more, a deep blue color should develop in one-half minute or less.

Known nitrate standards containing (say) 5, 8, 10, 15 and 20 ppm. of nitrate nitrogen should be run until the analyst becomes familiar with the rate and depth of color formation. All samples showing 10 ppm. or more of nitrate nitrogen in the screening process are run by the standard phenol disulfonic acid method for nitrates in water. Since such samples are high in nitrates, 5 ml. of the sample is taken for this analysis, and the reading obtained is multiplied by the appropriate factor.

Improvements to Hialeah Treatment Plant

By Clarence R. Henry

A paper presented on Nov. 19, 1948, at the Florida Section Meeting, Panama City, Fla., by Clarence R. Henry, Chief Chemist, Dept. of Water and Sewers, Miami, Fla.

THE water supply for Miami, Fla., comes from 20 wells located on the edge of the Everglades about 8 miles northwest of the central portion of the city. Averaging 90 ft. in depth with 14-in. casings and with a capacity of 3.5 mgd. each, these wells are operated in various combinations to meet a fluctuating demand which changes almost hourly. The treatment plant operates continuously throughout the 24 hours and a 40-mil.gal. day may have seen treatment of water at rates of from 30 to 50 mgd. Moreover, there is a large seasonal variation in water demand due to a tourist population in the winter, and, although most months show daily outputs of from 40 to 45 mil.gal., the total has been as high as 59 mil.gal. twice in February 1948.

This situation is reflected in the growth of the plant itself. Originally designed for a 10-mgd. capacity in 1924 (1), the Hialeah Water Plant, which furnishes all of the treated water used in the Greater Miami area, was enlarged to 20 mgd. in 1927 and to 40 mgd. in 1936. Completion of improvements and additions planned for the plant was expected by the end of 1948. These improvements provide for remote control of the individual wells, automatic control of much of the treatment process and an increase in capacity from 40 to 60 mgd. by increasing the filtration rate of the sixteen filters from 2.0 to 3.0 gpm. per square foot. Moreover, a change in the treatment process is involved as well. The addition of free residual chlorination will insure a more attractive and palatable water having a much lower color than is to be found at present.

The additions to the water plant and to the Miami water supply system have been described previously by Wertz (2). It is the purpose of this paper to outline the process of water treatment as practiced at present and to describe the operation and control of the proposed process.

Nature of Raw Water

As received from the wells, the water would not be acceptable for public use without treatment. It is hard, highly colored and has a distinct musty, weedy taste. The wells are located in a soft, porous limestone not far from the Miami Canal. As would be expected, the water from both the wells and the canal contains color and has the same general mineral balance, with the well water usually higher in alkalinity and lower in color. The well water composite as received at the plant has changed little since 1925. Table 1 shows typical average analy-

ses, for 1925 and 1948, of the water under discussion.

There was some salt water intrusion in 1939, when it was discovered that salt water from Biscayne Bay had flowed upstream because of a very low water level in the Everglades. Several wells became affected, which have since been improved by operating them one at a time in conjunction with the other wells of lower chloride content, in order to hold the composite chloride as low as possible. Meanwhile the well field has been protected by placing a dam across the Miami Canal during periods of low water level, and the location of salt water in the canal has been checked continually by means of samples taken once a week or oftener, at high tide.

The well water has certain obvious advantages as a raw water supply. Bacteriological tests run twice daily indicate that there is no contamination. The temperature is uniform throughout the year at 78°F., and there is little measurable variation in the chemical content. Magnesium and noncarbonate hardness are quite low. Nearly all hardness is present as calcium bicarbonate.

Because of the color present, or perhaps more correctly the organic matter thought to be associated with color, the water is rather difficult to treat. It can be assumed, moreover, that this color, derived from the decayed sawgrass and muck of the Everglades, is of an unusual nature. It is, as a matter of fact, much greener than the color of many other waters. So nearly does it match the yellow-green of the primary platinic chloride color standard of *Standard Methods* that no cobalt is added to alter the tint, and color standards must be made up from platinum metal alone.

Effects of Color

As very little is known about the composition of this color, it has been necessary to study its effect on various water treatment processes. Its apparent effect is to encourage supersaturation and to inhibit floc formation in lime softening. Coagulation with alum at a low pH, for the purpose of forming the so-called "color floc," is impractical because of the high alkalinity—that is, buffer capacity. The water is rather insensitive to the coagulant dosage in lime softening. With the Hialeah well water, at any given pH, 8.5 ppm. of alum will produce nearly as good a floc as any other dose up to 137 ppm. The use of this small amount does improve coagulation, however, and reduces color by about 5 ppm. more than when omitted. Although a softer water is produced, the floc resulting from undertreating the water is extremely fine and settles

TABLE 1

Typical Analyses of Raw Water

Item	Quantity—*ppm.* 1925*	1948
pH		7.3
Color	60	55–85
Ammonia nitrogen		0.50
Free carbon dioxide (CO_2)	25	21
Total dissolved solids		350
Silica (SiO_2)		9.0
Iron (Fe)		0.9
Calcium (Ca)	88	98
Magnesium (Mg)	12	7.1
Sodium & potassium (Na)		27
Total alkalinity ($CaCO_3$)	219	215–230
Sulfates (SO_4)		37
Chlorides (Cl)		35
Noncarbonate hardness ($CaCO_3$)		30
Total hardness ($CaCO_3$)	272	260
Hydrogen sulfide (H_2S)		1.2

* After Howson (1).

very slowly. It is also noted that many other local waters will not form a floc with alum and lime at all in any period that approaches the operation of either the conventional or the solids-contact type of plant. Of the various coagulants investigated, activated silica has given the best results. Small doses, 3 ppm. and less, are required, but give little or no color reduction.

Speaking again of simple lime softening with small doses of alum, the color, tastes and odors, though not well removed, are quite sensitive to the degree of treatment with lime. Typically, the color is reduced to 50–60 per cent of that of the untreated water with a lime treatment corresponding to a bicarbonate alkalinity of more than 20 ppm. as $CaCO_3$. When the treatment corresponds to an alkalinity of between 10 ppm. bicarbonate and 10 ppm. hydroxide, the color is reduced to 40–50 per cent of the original. On adding lime in excess, the color is further reduced to 30–40 per cent of the original. The usual plant operation has given final color values of 18 to 28 after chlorination and filtration of waters not so highly treated with lime. It is believed that some of the lower final color readings have been due to the further action of chloramine and sunlight, since very little color reduction has been observed to occur on allowing the water to stand for five hours in diffused light, or on passing the water through the sand filters at the plant.

Experimental Work

Experimental work has been conducted, both in the laboratory and on a pilot plant scale, to determine the feasibility of various treatment processes for both color removal and softening. Color removal was not obtained by the use of chlorine dioxide. Although colors were reduced by the use of ozone to as low as 10 to 13, the cost and operational difficulties involved were too great, because the high humidities encountered made necessary the drying of enormous quantities of air. Double treatment with excess lime and carbon dioxide, as well as lime softening followed by an alum color floc and stabilization, gave excellent results. Both methods were finally rejected because of their cost and complexity in operation and adaptation to the physical layout of the existing plant.

Although no true breakpoint could be found when chlorine was added to the raw water, and erratic results and unsatisfactorily high colors occurred on treating the water at the high pH due to the excess-lime treatment, the addition of larger doses of chlorine for the free residual chlorination of water in the pH range 7.5–7.8 was found to be superior to all other methods tried. It was decided that overtreatment with lime would not only produce less turbidity carryover from the clarifiers prior to the addition of carbon dioxide to lower the pH, but would also assure the operation of the free residual chlorination process by reducing and stabilizing the chlorine demand. Colors between 7 and 11 were consistently obtained by the use of this method of treatment. The further advantage of sterilization with free chlorine residuals at the plant and in the distribution mains as well made the process appear to be even more desirable.

Softening with excess lime, flocculation and clarification, pH reduction with carbon dioxide followed by free

residual chlorination, stabilization with sodium hydroxide and filtration gave excellent results not only in the laboratory and in the pilot plant, but also in several six-hour plant scale runs as well. This is the process selected for adaptation to the present plant at Hialeah and will be further described below.

Hialeah Plant Operation

Although many physical features of the Hialeah Water Plant have been changed, the treatment process, like the raw water itself, has altered little since the plant was built in 1924. It has been necessary to make changes in the water plant and at the same time to maintain a 24-hour-day production of water. This has been done with only minor interruptions since the beginning of construction in 1946. The older method of treatment will be continued until all the improvements and facilities necessary for the proposed operation are completed. For this reason, the general plan and flow diagram shown in the article by Wertz (*2*) published in 1946 may be used to illustrate both the present operation and the proposed one.

Control is manual and is based on frequent tests made by the operator. Water on entering the mixing tank is treated with a small excess of lime with 8.5 ppm. of alum added as a coagulant. Some aeration occurs as the water falls into two collecting troughs after rising through the sand trap and before chemicals are added. Since there is but 25 ppm. of carbon dioxide in the raw water, it is considered that additional aeration to remove it would cost more than the amount of cheap lime consumed by it. In the flash mixing tank, the water is thrust downward in the central portion by an electric-motor-driven two-bladed propeller and is circulated possibly two or three times before it can escape below the bottom baffle to go to the flocculator. Frequent tests of the alkalinity of the flocculator effluent are made to insure an even feed of lime, since the quality and size of the lime affect the quantity fed, and frequent changes in the pumping rate also occur.

Just beyond the flocculator, where the water is gently mixed for approximately 20 minutes to produce a floc that will settle, chlorine gas is added in the amount of 26 lb. per million gallons (3.1 ppm.). The feed is established in pounds per million gallons since the chlorine demand of the water changes little. Frequent tests of water from the sedimentation and the clear well are made to insure that the residual chlorine in water leaving the plant is maintained in the range of 1.0–1.5 ppm.

Alkalinity tests taken of the water before and after recarbonation serve to control the amount of carbon dioxide fed for stabilization. The carbon dioxide is obtained from No. 2 fuel oil which is burned in a small, firebrick-lined furnace and passed through a scrubber before being pumped directly into the water through a pipe grid at the bottom of the carbonation basin. Following stabilization the water is filtered.

Until a year and a half ago, ammonia was fed into the water before the chlorine to form chloramines, at the rate of 80 to 100 lb. a day, the capacity of the feeder. It was believed and proved in the laboratory that the uniform content of 0.4–0.5 ppm. of free ammonia in the raw water was quite sufficient to form stable chloramine

with the 3.1 ppm. chlorine fed. The use of ammonia was therefore discontinued, at a daily saving of from $16.00 to $20.00.

It was found desirable to return clarifier sludge to the raw water prior to the addition of the lime because of the rapid rate at which a deposit of calcium carbonate formed on all wet surfaces of the mixing tanks. This encrustation developed so rapidly, particularly at the points of greatest velocity in the mixing tank and on the effluent gates, stems and baffles, that it was necessary in the past to shut down the single mixing tank in service for cleaning—at a cost of $2,500—after 4½ months' use. Test specimens have indicated that the useful life of a single tank before cleaning would be doubled by the return of sludge in an amount equivalent to one-fourth of that formed in the softening of the water. This amount was the capacity of the piping installed for carrying the return sludge. Provision for the addition of more sludge will be made as soon as possible. The sludge is also added to the lime slurry at the chemical house to reduce encrustation in the lime feed line to the mixing tank.

Proposed Changes

The water will follow the same course through the plant as it does at present. After rapid mixing with lime and alum, the size of the floc will be built up so that as much as possible will settle out in the clarifiers. The pH will be reduced in the carbonation basin prior to the application of a breakpoint dose of chlorine. After 50 minutes' time in the chlorine contact basins, compressed air will be used for aeration, sodium hydroxide will be added for stabilization and the water will be filtered.

Raw water will enter the plant through two Venturi tubes having a carrying capacity of 28 and 44 mgd. respectively. These are connected directly by means of 1-in. lines to separate meters and recorders located in the chemical house approximately 115 ft. away. A summating and transmitting device will add the rates of flow given by the two meters—the total representing the rate at which water enters the plant for treatment—and will transmit this figure to a total flow indicator located in the operator's room approximately 300 ft. away. This same transmitter will also, by electrical means, operate the variable feed control on the two lime feeders and the soda ash feeder.

Two belt type gravimetric feeders are located on the second floor of the chemical house directly under two cylindrical steel lime storage bins. This lime will come through a pneumatic conveyor from the new lime-burning kiln (3) which will calcine the calcium carbonate sludge from the clarifiers. There will be more than enough lime and carbon dioxide produced above the water plant's needs to supply other users. These lime feeders, which automatically proportion the lime feed for the variable flow of water, each have a feed capacity of 5,000 lb. per hour of 95 per cent pebble lime and are adjustable from 500 to 5,000 lb. per hour in increments of 50 lb. Either one will feed enough lime for the maximum rate of treatment of 60 mgd. These feeders will, in turn, discharge into continuous slakers where the temperature is maintained by a thermostatically controlled water valve. The lime slurry pro-

duced will fall into a 250-gal. constant-level tank and be pumped directly to the mixing tank by means of a 3-in. line.

On leaving the mixing tank, the water will be gently agitated in the flocculators to build up the size of the floc and will go next to the three clarifiers, in parallel, for settling. It will leave the clarifiers with a turbidity of 4–8 ppm. and pass into the carbonation basin for pH adjustment prior to the addition of a 9-ppm. breakpoint dose of chlorine.

Control of pH

The water enters the carbonation basin from opposite ends, flows toward the center where the pH is lowered to approximately 7.5, and turns past the chlorine diffuser tubes. To measure the influent pH, the water will flow from the opposite ends of the basin through a 1-in. line at the rate of 2 gpm. to a flow type glass electrode cell and will overflow to waste. The cell is mounted inside a small compartment built for the purpose beside the center of the basin. The effluent pH will be measured by a similar glass electrode cell fed from an overflow pipe which will sample water after carbonation. Electric connections from both of the cells will lead to amplifiers in the same compartment and thence through 300 ft. of conduit to the operator's room, where the indicating dials and recorders are mounted.

Scrubbed gas, containing approximately 35 per cent of carbon dioxide, from the new lime-burning plant will be pumped through an 8-in. line, past a blowoff valve, to the diffusers in the carbonation basin. As the gas enters the basin, it will pass through a butterfly valve which is operated by air pressure acting on a diaphragm. Control of the pH is obtained by varying the volume of gas added against the pH of the effluent water. At the pH indicator, a "Free Vane Ampliset" * controller connects a compressed-air source, at 15 psi., with the butterfly valve diaphragm. This will convert changes of pH in the effluent water to changes in air pressure in order to give a proportional feed of gas.

Chlorination

Chlorine is added to the water as it leaves the carbonation basin to flow through the chlorine contact basins having a calculated retention time of 50 minutes. The control of the amount fed will be accomplished by the same Venturis which control the lime and soda ash feed and which operate the summator. A separate set of $\frac{3}{4}$-in. pipes from each Venturi will go to the chlorinator house, approximately 300 ft. away. Each will be connected with a converter which will control one chlorinator. These convert the differential pressure from the Venturis into the proportional vacuum which controls the feed of chlorine by the chlorinator. Manual control will be possible by simply shutting off the vacuum line connecting the converter to the chlorinator, after which the height of the adjusting tube can be regulated by hand.

Chlorine will be secured in tank cars and connected to the feed manifold at the railroad siding. The chlorine house contains chlorinators with daily capacities of 3,000 lb. and two automatic chlorine evaporators as well as the two converters for automatic control of the feed. These are so con-

* Manufactured by the Bristol Co., Waterbury, Conn.

nected that any two of the chlorinators may be used at once, leaving one for standby purposes. The capacity of each chlorinator will be sufficient to cover the chlorine demand of the water passing through the larger Venturi. As the previously determined chlorine dosage for breakpoint is 9 ppm., the 6,000 lb. per day of chlorine available from the operation of two of the chlorinators should be sufficient to treat 80 mgd., or 20 mgd. in excess of the designed capacity of the plant. On the other hand, that capacity will insure the application of chlorine to 60 mgd. of water at rates up to 12 ppm., without touching the standby. The control of chlorine feed will consist solely of maintaining the established dosage. The application rate will be verified and continuously checked by the operator and in the laboratory—by means of the Laux-Nickel test for free chlorine and by the use of a visual type comparator—for the amount of total available chlorine present, to determine the actual optimum range at the time. Since all of the basins and filters are uncovered and open to the sunlight, it is expected that the effect on the rate of reaction and on plant operation may require considerable attention for a time. Should there be any interruption of chlorine feed or apparent misfunctioning of the process, an immediate return to a simple combined residual chlorination of the water will be made until the cause is determined and corrected, since feeding some indeterminate amount of chlorine in the "hump" portion of the breakpoint curve would be very objectionable. As mentioned before, however, free residual chlorination of this water is predicated on several years of laboratory and pilot plant work and upon several six-hour scale runs as well.

Other Treatment

On leaving the chlorine contact basins, the water enters two aeration basins, connected in parallel, having a capacity of 390,000 gal. each. A total of 400 cfm. of compressed air will be forced through the water from a pipe grid at the bottom of the basins. The purpose will be to remove as much as possible of the nitrogen trichloride formed in the breakpoint reaction, as well as the free carbon dioxide and tastes and odors which may remain. The free chlorine residual may also be reduced somewhat, but at this point it is to be maintained in such a range as to give a free chlorine residual of 1.0 to 1.5 in the finished water.

Following aeration, sodium hydroxide will be added to the water for stabilization. It will be produced in an Accelator,* 15.5 ft. in diameter and 18.35 ft. deep, located adjacent to the chemical house. A maximum of 300 gpm. of treated water will be passed through it at a constant rate, and lime and soda ash will be added in order to produce sodium hydroxide in accordance with the reaction of 1 mol of calcium hydroxide with 1 mol of sodium carbonate to give 1 mol of calcium carbonate and 2 mols of sodium hydroxide:

$$Ca(OH)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2\ NaOH$$

The amount of soda ash will be proportioned through the dry chemical feeder by the same transmitter which controls the feeding of the line. A small quantity of the total lime fed in the treat-

* Made by Infilco, Inc., Chicago.

ment of the water in the plant will be diverted from the 3-in. line to the mixing tank by means of an adjustable feed pump. After initial adjustment of this volume, a constant rate will be maintained, and the proportioning of the lime feed for stabilization will come from the lime concentration in the slurry. The amounts of lime and soda ash necessary to produce sodium hydroxide for stabilization have been calculated as 5.9 and 8.4 ppm., respectively, or a total of 2,940 and 4,200 lb. for 60 mgd. The sodium hydroxide will be added to the water at the four points where it leaves the aeration basins for the filters. After it has been filtered, the water is ready for distribution.

Cost of Additional Chemicals

The same amounts of lime and alum are required for softening in both the older process and in the proposed one, and both make use of carbon dioxide in the adjustment of pH. Since in the future carbon dioxide will be a waste product from the new lime kiln, the cost will be negligible. The required additional chemicals necessary in changing over to the proposed process are the 49 lb. of lime and the 70 lb. of soda ash used in producing the sodium hydroxide necessary for stabilizing each million gallons of water treated, and the 49 lb. of chlorine required to raise the total feed of chlorine from 26 to 75 lb. per million gallons. The estimated prices for these chemicals are $9.90 a ton, $27 a ton and 3¢ a pound, respectively. Based on these prices, the cost of the additional chemicals should be $2.67 for 1 mil.gal. of water treated.

This treatment is expected to reduce the color, taste and odors of the finished water and to carry a residual of free chlorine into the distribution system. In other words, the purpose will be to produce a more palatable and attractive water in the future and to make it a safer water bacteriologically when it reaches the consumer.

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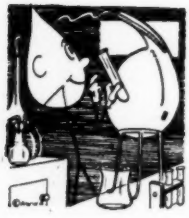

Use of Commercial Carbon Dioxide in Lime Softening

By Fred G. Gedge

A paper presented on Oct. 8, 1948, at the Ohio Section Meeting, Mansfield, Ohio, by Fred G. Gedge, Supervisor, Village of Wyoming, Cincinnati, Ohio.

OF all the operations involved in a water softening plant using the lime–soda ash process, probably the most troublesome is the recarbonation step. The conventional method of water stabilization utilizing carbon dioxide derived from flue gases has been found inflexible in response to changing loads and expensive to maintain. It is frequently out of service because of the repairs required and demands almost constant attention by an operator to assure proper yields of carbon dioxide.

This method of producing carbon dioxide has been replaced at the Wyoming, Ohio, water works by the direct application of high-purity commercial carbon dioxide with very good success, and it is felt that the commercial product will find wide acceptance among water plant operators once its application is understood and its advantages are studied.

Wyoming Plant

The softening plant at Wyoming, Ohio, which was built in 1930, provides a capacity of 1.5 mgd. At present it serves primarily a residential population of 12,500. The raw water, which is supplied from four wells, averaging 200 ft. in depth, has a total hardness of 440 ppm., composed of 327 ppm. of carbonate hardness and 113 ppm. of noncarbonate hardness.

A brief description of the plant equipment may be pertinent. At Wyoming, mixing, flocculation, clarification and recarbonation are all carried out in one vertical steel cylindrical tank 40 ft. in diameter and 36 ft. high. At the center of this tank is a tubular downcomer 10 ft. in diameter, which extends downward to within 5 ft. of the tank bottom. There is a fixed set of baffles in a circular trough around the top of the downcomer. The raw water enters at the top of the downcomer in this trough, where a slurry of treating chemicals is also added. Floc formation occurs as the mixed chemicals and raw water flow around the trough down through the downcomer. The dosages of treating chemicals are: 374 ppm. lime (75 per cent CaO); 75.5 ppm. soda ash; 18.1 ppm. alum; and 11.3 ppm. vitreous phosphate.*

The clarification of the water takes place as it flows upward through the sludge pool from the bottom of the downcomer to the top of the main tank. The clarified water then flows from the top of the tank into and down another vertical downcomer, located at the side of the main tank, 3 ft. in diameter and extending to the bottom. As the water

* Made by Calgon, Inc., Pittsburgh, Pa.

flows downward it comes in contact with the carbon dioxide bubbling upward. From this point the water leaves the tank and flows to the filter gallery, consisting of two gravity sand filters 15 × 16 ft. in area and 10 ft. deep. After passing through the filters, the water flows to the clear well, from which it is pumped to the distribution system. A typical analysis of the water at various stages through the plant is given in Table 1.

Since the theory of, and the reasons for, recarbonation are well understood, it will not be necessary to go into the various chemical reactions and results obtained.

Equipment

The gas generation equipment in use at Wyoming prior to the installation of commercial carbon dioxide facilities consisted of a household type of hot-air furnace having a grate area of 3 sq.ft. and a scrubber 4 ft. in diameter and 10 ft. high with a packed height of 3 ft. of crushed limestone packing. The flue gas passed counter-current upward against a flow of water sprayed downward over the packing. From the scrubbers the scrubbed gas entered the compressor, a horizontal, single-acting reciprocating machine powered by a 10-hp. variable-speed electric motor. The compressed gas then flowed to a distributor located at the bottom of the downcomer at the side of the main softening tank, where the gas came in contact with the settled water from the tank.

This conventional type of apparatus was replaced by equipment for the storage and utilization of carbon dioxide in its solid form, dry ice. The dry ice is delivered to the plant in the form of 50-lb. cubes, approximately 10 in. on a side. Each block is then broken into perhaps four pieces for easy loading into the dry-ice converters. When the dry ice is in the converters, the charging opening is closed at the top by means of an elliptical handhole closure similar to the type used in boilers. With the valves closed, the dry ice becomes liquid and gas by absorbing heat from the surroundings. Under normal room conditions, the conversion requires about 24 hours. The six converters at Wyoming, each of 150-lb. carbon dioxide capacity, are 13 in. in diameter and 6 ft. in height. They are manifolded together by suitable connections so that any or all may have gas drawn from them simultaneously.

TABLE 1

Typical Water Analysis

Water Stage	Avg. Alkalinity—*ppm.*		Total Hardness *ppm.*
	Phenolphthalein	Methyl Orange	
Raw	0	324	432
Settled			
Before carbonation	42	81	
After carbonation	28	79	
Final	17	53	96

Usually gas is taken from two at a time, with four full converters in reserve. When two are empty, as indicated by a pressure gage, they are cut off from the manifold by closing two valves, and two fully charged units are cut in.

Since the pressure of the carbon dioxide within the converters is, at normal room temperatures, approximately 850 psi., it must be reduced and controlled before the gas can be fed into the water. This is accomplished by placing a regulator on the line. By adjustment of the regulating screw a

wide variation of flows may be obtained. From the regulator the gas passes through a rotameter, the use of which permits the gas flow to be instantly set at any desired rate within the capacities of the regulator, the rotameter and the vaporization rates of the converter.

The carbon dioxide is run from the rotameter through copper tubing to the diffuser in the recarbonation downcomer. The diffuser consists of a 15-ft. length of porous canvas hose called a "soil soaker" (used in watering gardens), which is clamped to the copper tubing at the top and weighted at the bottom with a heavy iron weight. The soil soaker, sealed at the bottom, is so arranged in the downcomer that the lower end is resting on the bottom. The purpose of the soil soaker is to disperse the gas into fine bubbles, which assures its efficient utilization.

In operation, the amount of carbon dioxide fed is controlled—as in the conventional method of recarbonation—to give phenolphthalein and methyl orange alkalinity readings at points before and after the sand filters. Should the pH readings at these points start rising, the gas flow is increased through a simple adjustment of the gas regulating valve. If, on the other hand, the alkalinity readings fall, the amount of carbon dioxide fed is reduced. Visual indication of the gas flow is provided by the rotameter installed in the line which gives accurate and instantaneous gas flow readings. The quantity of gas fed varies from time to time with the quantity and quality of lime fed; however, it averages very close to 12 ppm.

Advantages of Commercial CO_2

The use of commercial carbon dioxide has resulted in advantages to plant operation which strongly recommend its adoption:

1. Reduction of filter loads. Through uniformity and continuity of treatment, filter runs have been extended 25 per cent.

2. Saving in backwash water. For the same reasons as given for longer filter runs, the quantity of backwash has been reduced by an estimated 20–25 per cent.

3. Improved physical condition of filters. An examination of the filters after nearly a year's operation revealed generally cleaner sand particles and a marked reduction in mudball formation, compared with conditions when using flue gas.

4. Saving in labor. It is estimated that in this plant the saving amounts to as much as 30–40 per cent. Although there is no actual dollar saving, labor is freed for other activities.

5. Increased cleanliness. The general plant appearance has been much improved through the elimination of the soot and ashes involved in the storing and burning of coke.

6. Uniformity of treatment. Because of the ease in adjusting carbon dioxide dosages, water leaving the plant is neither under- nor overtreated. This results in improved water quality, in addition to the other advantages listed above.

7. Elimination of taste and odor complaints. In the past occasional complaints were received arising out of sulfurous tastes and odors, which were traced to the faulty scrubbing of gas produced from high-sulfur cokes. There is no possibility of recurrence now.

8. Elimination of shutdowns for maintenance on furnace, scrubber and compressor. Previously these opera-

tions left the plant withhout carbon dioxide for as long as two or three days.

Cost Comparison

Because of the difficulty in measuring certain items, cost comparisons appear to place the use of commercial carbon dioxide at more of a disadvantage than actually exists. Using flue gas for recarbonation, the computed costs were $0.003 per thousand gallons of treated water, including fixed charges, coke, power and maintenance materials, but not including either operating or maintenance labor, or compressor and scrubbing water. Using high purity commercial carbon dioxide at $0.035 a pound, the present costs are running $0.006 per thousand gallons. No credit is given in the 6-mill figure for the savings effected in labor and backwash water, or for the expected saving accruing from longer filter life.

It is felt that, despite this apparent cost disadvantage, the benefits outlined above, together with the intangible savings, serve to recommend serious consideration of commercial carbon dioxide for use in municipal lime softening plants.

Revision of 7H.1 Tank Specifications

On September 20, 1948, the text of the "Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs—7H.1–1943" of the A.W.W.A., American Welding Society and New England Water Works Assn. was extensively revised and brought up to date. Many of the references to A.S.T.M. and other specifications for grades of materials used in fabrication have been altered, and there have been numerous revisions in welding procedures and tests. Most heavily affected are Sections 2, 3, 8, 10 and 11, with the remainder of the changes occurring in Sections 9, 12 and Appendix A9. The revisions are so numerous that users of the specifications will find it impracticable to make corrections in their copies of the older document. The revised document will be published in the JOURNAL at a later date, and the text of the revision, under the designation 7H.1–1948, is now available as a 35-page booklet, priced at 35¢ per copy.

Mechanism of Flocculation in the Clarification of Turbid Waters

By W. F. Langelier and Harvey F. Ludwig

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by W. F. Langelier, Prof. of San. Eng., Univ. of California, Berkeley, Calif., and Harvey F. Ludwig, Cons. San. Engr., Ludwig Bros., Pasadena, Calif.

FLOCCULATION is one of the most important unit processes employed in the purification of natural waters, and flocculation phenomena are inherent in most final processes of sewage treatment. The process has great theoretical interest because of the many variables encountered in practice which influence clarification efficiency. Early studies of flocculation in the Sanitary Engineering Laboratories at the University of California at Berkeley led to: [1] the development of suitable apparatus and techniques for laboratory study, [2] the indication of the importance of pH and alkalinity in flocculation and [3] the indication of the importance of controlled and prolonged agitation in shortening the time required for effective coagulation and clarification. A discussion and summary of these findings was published (1) in 1921.

In these earlier studies, little attempt was made to explain critically the causes of all of the phenomena observed, and even to this day, in spite of an extensive literature developed by many investigators in the intervening years, there still remains in the minds of water technologists considerable obscurity and confusion about basic phenomena. Most of the work done in this field has centered on the chemical characteristics of the coagulant chemicals and the chemistry of the dissolved constituents of the water. Except for distinguishing the general behavior of organic and inorganic colloids undergoing flocculation, little detailed attention has been given to the chemical and physical properties of the particles constituting the turbidity.

In a continuation of the university program (2-4) a systematic study was made of synthetic waters prepared by dispersing in water the colloidal or clay fraction of a variety of soils, the chemical and colloidal properties of which had been previously evaluated in the university's department of soil science.

Comprehensive flocculation studies were undertaken with these waters employing numerous different coagulants and combinations of coagulants, and the flocculation data thus obtained were compared with the known soil properties to determine whether any significant relationship existed. The comparisons clearly demonstrated that one of the soil properties—namely, the cation or base exchange capacity of the colloidal soil fraction—bears a direct relationship to flocculation phenomena. It is the purpose of the present paper

to consider briefly the nature of clay turbidity particles, to review certain of the laboratory data obtained and to conclude with a general formulation of the principles of flocculation behavior as it relates to inorganic turbidities.

Nature of Clay Turbidity

Most turbid waters are essentially suspensions of colloidal clay particles in a water medium, the clay particles having been introduced or dispersed into the medium through the hydraulic erosion action of runoff waters on soils. Colloid chemistry teaches that the suspended particles tend to remain in that condition because of the existence of an electric double layer surrounding the nucleus or core of each particle. At the surface of the core reside fixed negatively charged oxygen and hydroxyl anions, which make up the inner part of the double layer. The outer layer comprises an envelope of oscillating positively charged cations, which diffuse into the closely surrounding water medium. It has been estimated that the order of magnitude of ion concentrations within the double layer may be as great as 1–2 *N*. Except for this double layer, suspended particles would soon aggregate and settle out, because there exists between all such particles inherent forces of attraction. Aggregation is, however, prevented by the mutually repelling action of the positively charged outer layers. The types of cations predominating in the outer layer depend upon the properties of the clay from which the turbidity particles were derived and also upon the ionic content of the water. Moreover, since these cations are held in place by adsorption, they are replaceable upon addition of a suitable electrolyte to the water. The cations are commonly designated "adsorbed," "replaceable" or "exchangeable." The replaceable cations generally found in soils, arranged in increasing order of the strength to which they are adsorbed, are Na^{+}, K^{+}, Mg^{++}, Ca^{++}, H^{+}, Al^{+++} and Fe^{+++}. Thus, particles whose exchangeable cations are principally Na^{+} or K^{+} are very stable and settle, if at all, very slowly. Those containing principally Fe^{+++} or Al^{+++} will be only very slightly stable, and the interparticle forces of attraction will soon cause them to agglomerate and settle.

The degree to which nonadsorbed cations in the water medium will exchange positions with cations in the outer layer is governed by the law of mass action. That is, the amount of exchange will depend upon the character and concentration of the ions involved. In general, cations of higher valence will displace cations of lower valence. Other factors, however, such as the size of the ion and the nature of the anions present, are important. By the proper selection of an added salt, the electric double layer may be repressed in thickness and the forces of repulsion reduced, until a critical "zeta-potential" is reached, at which the forces of repulsion can no longer prevent aggregation by the normal forces of attraction. The ζ-potential is obtained by calculation from measurements of the velocity of movement of colloid particles in an electric field. For clay colloids, the critical ζ-potential for rapid coagulation is of the order of from 20 to 40 mv. Zero ζ-potential is called the isoelectric point.

The aggregation of particles which occurs as a result of repression of the

double layer to a sufficiently low potential level is called either coagulation or flocculation. Coagulation of this type may be described as "rapid" or "slow" depending upon the extent of repression. Soil chemists refer to it as "perikinetic" coagulation (5), in order to distinguish it from "orthokinetic" coagulation, which is a filtering action wherein small particles of low potential are merely entangled by larger particles, as in sedimentation. Essentially, however, there is only one basic type of coagulation of clay colloids, and this is due to charge neutralization. Some chemists regard coagulation as only a first step toward flocculation, in which both perikinetic and orthokinetic coagulation may occur. Something analogous to this is what actually occurs in water purification. Here, the process of perikinetic coagulation, of itself and unaided, is normally unsatisfactory because of the relatively large dosages of chemical required, the relative slowness of the reactions involved and, usually, the deterioration in the quality of the product. In water purification practice, the presence of a binder material or flocculation aid to assist the perikinetic action is normally required for efficient results. If this binder material carries a small positive electric charge, its efficiency will be still further increased through "mutual" charge neutralization. Obviously, the most rapid clarification will be obtained when the ultimately formed flocs attain a zero potential. The most common method of attaining flocs of zero or near-zero potential is the selection of a coagulant chemical which, in addition to yielding cations of high positive valency to effect perikinetic coagulation, will also yield through hydrolysis a flocculant precipitate which serves as a binder material to accelerate the processes of aggregation. In any event, efficiency demands that there shall be a proper balancing of the ion exchange and hydrolysis effects. Depending upon the character of the water with respect to buffer capacity, pH and the like, the use of more than one chemical may be desirable.

In the following discussion, an attempt will be made to show from experimental data that only by recognizing the flocculation process in water treatment as the attainment of a proper balance between exchange adsorption and hydrolysis resulting in a near-zero potential is it possible to reconcile the many apparently inconsistent phenomena observed in flocculation practice.

Laboratory Studies

In order to simulate natural turbid waters, synthetic waters were prepared by a standardized fractionating procedure (*2*) in which only the colloid fraction of the soil particles of approximately 0.001-mm. diameter and smaller were retained. Ten different soils of widely different characteristics were employed, these having been selected to represent as nearly as possible the major types of soil groups prevalent throughout the United States. The resulting turbid waters were analyzed to determine: initial pH, initial alkalinity, initial turbidity and also the concentration of suspended soil colloids in milligrams dry weight per liter. These properties are listed in Table 1, together with data identifying the various soils employed. Also listed is the exchange capacity, E, of the suspension in microgram equivalents

TABLE 1—*Soil Types and Properties of Synthetic Turbid Waters*

Soil No.	Soil Type	Source of Soil Sample	Predominant Clay Mineral	Water Sample No.	Weight of Suspended Material *mg./l.*	Initial Turbidity *ppm.*	Exchange Capacity—*me./l.*			Initial pH	Initial Alkalinity (as $CaCO_3$) *ppm.*
							Total	Replaceable Na^+	Replaceable Ca^{++}		
1	Yolo dark-colored adobe clay	Santa Clara Co., Calif.	Montmorillonitic	1A	151	70	101	0	101	6.9	4
				1B	508	175	340	340	0	8.85	19
2	Vina clay loam	Butte Co., Calif.	Kaolinitic	2A	135	58	81	0	81	6.9	4
				2B	520	120	312	312	0	8.1	14
3	Redding loam	Shasta Co., Calif.	Kaolinitic	3A	214	120	42	0	42	7.0	4
				3B	226	120	45	45	0	6.95	8
4	Maxwell adobe clay	Napa Co., Calif.	Montmorillonitic	4A	268	110	174	0	174	7.15	4
				4B	970	150	632	632	0	8.8	13
5	Fresno fine sandy loam	Fresno, Calif.	Muscovitelike	5	84	45	22	5	17	7.0	8
				5A	62	35	16	0	16	7.0	5
				5B	66	45	17	17	0	7.5	9
6	Fresno fine sandy loam (gypsum reclaimed)	Fresno, Calif.	Muscovitelike	6	80	43	21	1	20	7.0	4
7	Rosamond clay	Mojave Desert, Calif.	Muscovitelike	7A	600	210	204	0	204	7.7	37
				7B	988	390	335	335	0	9.0	48
8	Fallon silt loam	Fallon, Nev.	Muscovitelike	8	74	30	28	2	26	8.3	7
9	Sunrise silty clay	Temple, Ariz.	Muscovitelike	9	188	75	65	25	40	7.4	21
				9A	188	70	65	0	65	7.0	21
				9B	275	100	95	95	0	8.8	21
10	Unnamed clay loam	Brigham City, Utah	Muscovitelike	10	174	52	46	35	11	7.6	19
				10A	94	50	25	0	25	8.4	14
				10B	101	58	26	26	0	8.8	17

per liter (μe./l.). This was calculated from cation exchange measurements of the original soils employing the ammonium acetate method, by multiplying the exchange capacity of the soil by its concentration in the water as determined by weighing the residue left upon evaporation of a portion of the sample to dryness.

As indicated in Table 1, two or more different waters were prepared from each of the ten soil types. Waters designated with an "A" suffix indicate soil previously leached with a strong calcium chloride brine, so that the soil colloids, by exchange adsorption, have become "saturated" with Ca^{++} ions. Waters designated "B" indicate soil previously leached with a strong sodium chloride brine, and therefore saturated with replaceable Na^{+} ions. Waters without a suffix were prepared from the unleached soils, and consequently their colloid particles contain both replaceable calcium and sodium ions in the proportions existing in the original soil. Twenty-one different waters were prepared and examined for their flocculating properties. It is of interest to note that, although the samples were prepared with distilled water, there is reported for each a titratable alkalinity. Because this alkalinity is a property of the suspended matter, it might properly be called "apparent" alkalinity. In general the Na- turbidities yield higher pH values and alkalinities than do the Ca- turbidities. It might be expected that the alkalinities should be proportional to the expressed values for total exchange capacity because each is a result of the adsorption of cations. There is, in fact, a degree of correlation. The lack of correlation, where it exists, can be readily explained by the fact that the avidity of the different turbidities for the hydrogen ion, involved in the determination of apparent alkalinity, is not the same as for ammonium ions involved in the total exchange capacity measurements, and also by the fact that in the former determinations complete exchange equilibrium is not attained.

Also of interest are the values for the coefficient of fineness obtained by dividing the weight of suspended material by the turbidity readings. These values are higher and less uniform for the Na- turbidities than for the Ca- turbidities.

Flocculation Tests

The flocculation tests were conducted with a stirring device in common laboratory use, consisting of a battery of eight jars, each containing 200 ml. of the sample and equipped with a paddle stirrer revolving at 72 rpm. A stirring period of ten minutes was allowed, followed by a settling period of either fifteen minutes or twelve hours (overnight). Chemicals were added immediately after the beginning of stirring; and when several chemicals were used for the same test portion, those which form hydrous oxides through hydrolysis were added last. After the designated period of settling, the top 100 ml. of the sample was poured off, and the following measurements were made on this supernatant: turbidity, designated "final turbidity" (T_f); and pH, designated final pH (pH_f). The quality of the floc was graded as excellent, good, fair, poor and incipient, according to the observed size, density, toughness and rate of settling of the floc particles. Almost without exception, it was found that a low final turbidity (10 ppm. or

less) corresponded only with a floc of high quality, and for this reason the floc quality data have been omitted from the tabulations.

All together, several thousand different tests were made, employing a variety of coagulant chemicals: $Al_2(SO_4)_3 \cdot 18H_2O$ (alum), $AlCl_3$, $FeCl_3$, $Fe_2(SO_4)_3$, $FeSO_4$, $Th(NO_3)_4$, $LaCl_3$, $CaCl_2$, NaCl, Na_2SO_4, $Ca(OH)_2$, NaOH, HCl, sodium hexametaphosphate, methylene blue (a positively charged colloid) and various bentonites. It is not possible to review here all of the data obtained, and this discussion has been limited to a consideration of the results obtained with calcium chloride and with alum.* For each of the 21 different waters, the tests considered comprised four series, made according to an identical schedule: Series 1—calcium chloride (varying: 0–100 me./l.); Series 2—alum (varying: 0–2,000 ppm.); Series 3—alum (varying: 0–200 ppm.); and Series 4—alum (varying: 0–100 ppm.) and calcium chloride (5 me./l.). In Series 1, 2 and 4, 0.5 me./l. (milligram equivalents per liter) of sodium bicarbonate was added; in Series 3, none was added. The settling periods were fifteen minutes and twelve hours in Series 1 and fifteen minutes in each of the others. The sodium bicarbonate was added to most of the test waters to furnish a carbonate alkalinity comparable to that of natural turbid waters.

* The present contribution is limited to what are regarded as basic considerations. It is proposed to discuss in a future paper some of the remaining data relating particularly to efficiencies of other coagulants including acids and bases. Also remaining to be published are data on the effects of certain anions which form complexes with aluminum and other metals.

Representation of Flocculation Data

Flocculation data are most effectively interpreted by the use of flocculation curves. Chemical dosages are usually plotted as abscissa and a suitable variable, generally the residual or final turbidity, as ordinate. Other types of curves have been found useful. Figure 1, for example, embodies the results of a large number of jar tests and shows the flocculation characteristics of turbid waters derived from various soils. In Fig. 1 the coagulant demand or most efficient dosages of chemical have been plotted against the total alkalinity (the numbered circles represent the pH_f at the most efficient dosages). The coagulant demand, D_e, is defined as that minimum dosage which is found to reduce the turbidity 80 per cent or more. Figure 1 shows that, whereas the type of clay turbidity materially affects the coagulant demand, for any given clay the coagulant demand increases with the total alkalinity. The curves also show that for a particular clay the pH at the most efficient dosage (D_e) increases with the total alkalinity but that for a given alkalinity the pH values at the most efficient dosage are reasonably equal for the different clays.

Figure 2 shows "standard" curves in which the chemical dosage is plotted against the residual or final turbidity of the supernatant. These curves are schematic, being intended to indicate the relative differences in clarification efficiency of (*a*) unaided perikinetic coagulation of a normal water with respect to time and (*b*) combined perikinetic and hydrolytic actions followed by unaided perikinetic action, obtained with the use of a hydrolyzing coagulant. Taken as a whole, the figure in-

dicates that, for ordinary waters, perikinetic coagulation or coagulation in the absence of hydrolysis is relatively inefficient. It will be noted that the hydrolyzing coagulant curve is divided into four zones. In Zone 1, there is no clarification, presumably because the tendency of the dissociated aluminum ions to become adsorbed by the clay particles is sufficiently great to prevent the formation of hydrous aluminum oxide by hydrolysis—that is, the exchange reactions must be practically completed before hydrolysis begins. In Zone 2, hydrolysis begins and reaches a maximum at the point of minimum turbidity in the left half of the zone. The onset of hydrolysis is assumed to be determined by both the ζ-potential, which is rapidly falling because of adsorption in the first zone, and the pH of the system. With further increased dosages, the turbidity reduction decreases until it is zero at the end of the zone. The width of this zone and the pH at the point of reversal are functions of the buffer capacity or total alkalinity. The reversal point is sharpest in the presence of low total alkalinity. It is presumed that, at the termination of the zone, the hydrolysis conditions are the same as obtain in a dilute solution of an alum salt in distilled water where the basic product of the hydrolysis reaction appears to be in true solution. A most likely explanation is that basic ions of the type $Al(OH)_2(H_2O)_4^+$ and $Al(OH)(H_2O)_5^{++}$ or other complexes are formed. Zone 3 can be regarded as a continuation of Zone 1, in which the ζ-potential continues to fall but not sufficiently to bring about rapid coagulation. In Zone 4, the concentration of

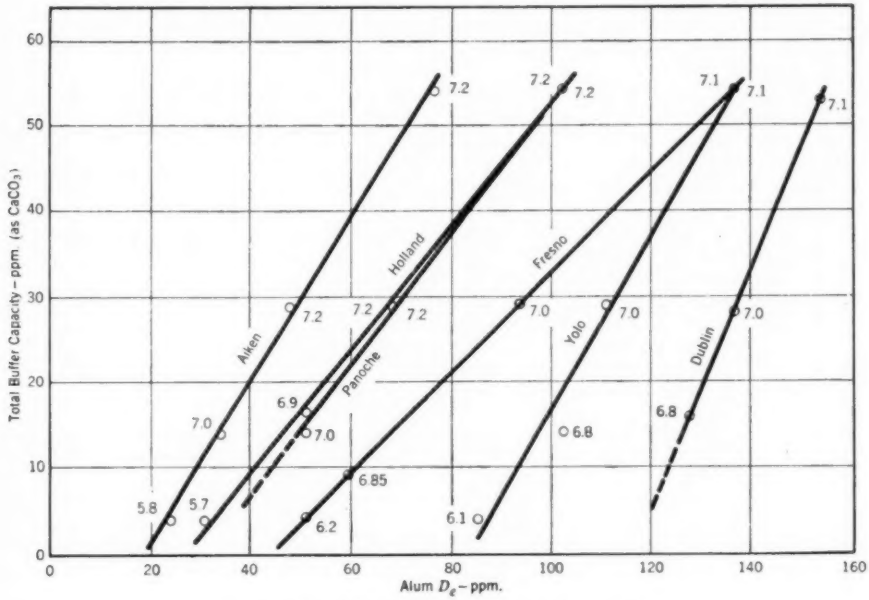

FIG. 1. Flocculation Curves for Various Soils

TABLE 2—*Flocculation With Calcium Chloride (Series 1 Tests)*

Water Sample No.	15-min. Settling Period					12-hr. Settling Period						
	Most Efficient Dosage, D_e		Residual Turbidity at D_e ppm.	Incipient Dosage		Most Efficient Dosage, D_e		Residual Turbidity at D_e ppm.	Incipient Dosage		Lowest Residual Turbidity	
	me./l.	multiples of E		me./l.	multiples of E	me./l.	multiples of E		me./l.	multiples of E	ppm.	Dosage Effecting me./l.
1A	50	495	60	20	198	4.0	40	10	2.0	20	5	7.5
1B	5.0	14.7	15	1.5	4.4	2.5	7.4	5	0.7	2.1	5	2.5
2A	50	618	50	25	310	4.0	49	7	2.0	25	5	5.0
2B	2.6	8.3	30	1.6	5.1	1.5	4.8	10	0.77	2.5	8	4.0
3A	25	595	100	7	167	4.0	95	12	1.4	33	12	4
3B	6.0	135	100	5.0	112	4.0	90	14	1.5	34	10	6
4A	25	143	70	4.0	23	2.0	11.5	20	1.05	6.0	10	6
4B	2	3.2	5	0.9	1.4	1.0	1.6	3	0.6	0.95	3	1
5	no flocculation			100 +	4,600	10.0	460	10	2.5	116	5	50
5A	no flocculation			100 +	6,300	10.0	630	15	5.0	315	10	50
5B	incipient flocculation			100 +	5,900	15.0	885	11	2.5	147	7	50
6	no flocculation			100 +	4,800	20.0	950	10	6.5	310	7	50
7A	5.0	24.5	80	3.0	14.7	2.0	9.8	20	1.5	7.4	10	40
7B	5.0	14.9	90	3.5	10.4	2.0	6.0	30	1.5	4.5		
8	no flocculation			100 +	3,600	3.5	130	10	2.0	72	5	10
9	50	775	65	35	542	10.0	310	20	1.0	15.5	10	50
9A	20	310	67	10	155	10.0	310	5	2.0	31	5	10
9B	6.0	63.5	80	4.7	50	2.0	21	10	1.3	14	7	5.5
10	no flocculation			100 +	2,200	10.0	440	5	2.0	44	5	10
10A	no flocculation			100 +	4,100	9.0	370	15	4.0	163	12	25
10B	no flocculation			100 +	3,800	10.0	760	10	3.0	114	5	25

active cations is now very high and sufficiently great to lower the potential to the critical level necessary to effect rapid perikinetic coagulation. The type of flocculation occurring in Zone 2 is hereafter termed "normal flocculation," to differentiate it from the "high-range" flocculation which occurs in Zone 4.

In the discussion below, the subscript e, added to the symbol D, implies "most efficient dosage" or coagulant demand. Similarly the subscript b implies "incipient coagulant demand," or that dosage at which the turbidity drop is about 20 per cent of that attained at most efficient dosage.

Unaided Perikinetic Flocculation

The Series 1 tests were undertaken to study directly the effects of perikinetic action. Calcium chloride was selected as the coagulant in order to avoid the formation of precipitates through hydrolysis. Calcium ions are not as strongly adsorbed as Al^{+++} ions and consequently have a lesser charge-neutralizing effect for any given dosage. It is, however, possible to effect perikinetic flocculation with divalent cations by using larger dosages, and therefore in these tests a wide range of dosages, up to 100 me./l., was employed. Also, to permit a more critical observation of the perikinetic effects, turbidity measurements were made after a settling period of twelve hours, as well as after fifteen minutes. The results of the tests using calcium chloride as the coagulant are given in Table 2 and are graphically shown in Fig. 3 and 4.

In Fig. 3 are plotted the dosages of calcium chloride which were required to effect incipient flocculation (D_b), and also the most efficient flocculation (D_e), for each of the 21 waters of varying exchange capacity, in the presence of 0.5 me./l. added carbonate alkalinity (the solid curve and plotted points represent D_b values at fifteen minutes' settling). In this figure, the chemical dosages are expressed in multiples of the exchange capacity, E, of the individual waters. Three important and fundamental conclusions are made evident by the curves: [1] the dosage of coagulant necessary to effect perikinetic flocculation is dependent only upon the exchange capacity, E, and is independent of the relative percentages of replaceable sodium and calcium; [2] the coagulant dosage, expressed in terms of multiples of E, decreases as the value of E increases; and [3] rapid agglomeration and clarification may be effected with calcium chloride as the coagulant only when E is of the magnitude of 250 μe./l. or greater. All of these conclusions are

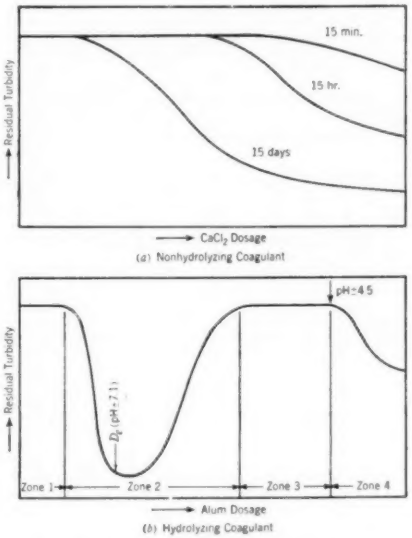

FIG. 2. Standard Flocculation Curves

believed to be in harmony with accepted theories of colloid chemistry. Conclusion [1] indicates that the calcium-saturated clay particles, although of lower initial stability than sodium-saturated particles, have less tendency to enter into exchange reactions, and consequently the necessary dosages for effecting visible clumping agglomeration and clarification may be effected by perikinetic action alone or without the aid of binder material.

In Fig. 4, selected data from Table 2 are plotted in the standard form, residual turbidity * against dosage. Curves *A* and *B* represent a water with a low exchange capacity of 50 μe./l. and curves *C* and *D*, a water with a high

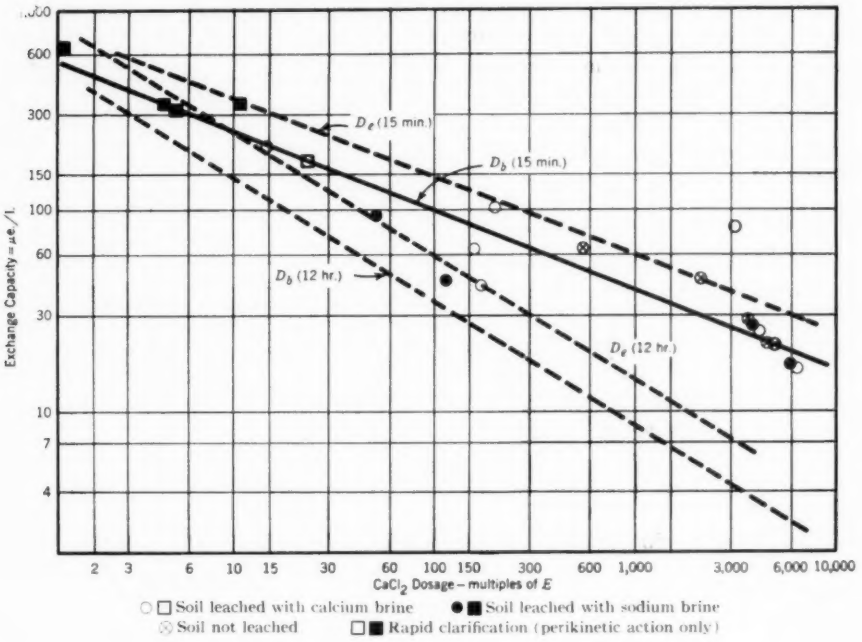

FIG. 3. Relation of Exchange Capacity to $CaCl_2$ Dosage

are approximately the same for both. Conclusions [2] and [3] both indicate the effect of concentration of particles —the greater the concentration the greater the proximity of the particles and the more easily a clumping action is induced; and, when the exchange capacity reaches a critical limit of approximately 250 μe./l., the tendency toward clumping upon perikinetic flocculation becomes so great that rapid exchange capacity of 250 μe./l. Curves *A* and *B*—for a fifteen-minute and twelve-hour settling period, respectively—indicate that, with ordinary waters of low exchange capacity, no appreciable clarification results from perikinetic coagulation over a short settling period, but that, nevertheless, the turbidity is partially destabilized and clarification is effected over the longer

* In per cent of initial turbidity (T_i).

settling period. Curves *C* (fifteen-minute period) and *D* (twelve-hour period) indicate that unusual waters of very high exchange capacity may be clarified rapidly by unaided perikinetic coagulation.

Although waters of high exchange capacity are of rare occurrence, as turbid waters can be clarified by adding more turbidity—that is, by treatment with sodium-bentonite and lime.

An uncommon natural water of very high exchange capacity—one which it was found could not be treated successfully in a plant of standard design—was encountered in 1944 on San Clemente Island off the coast of southern California. The turbidity of this water (2,300 ppm.) was completely stable, showing no settlement even after several weeks of quiescent standing in the laboratory. Experiments indicated that flocculation and excellent clarification

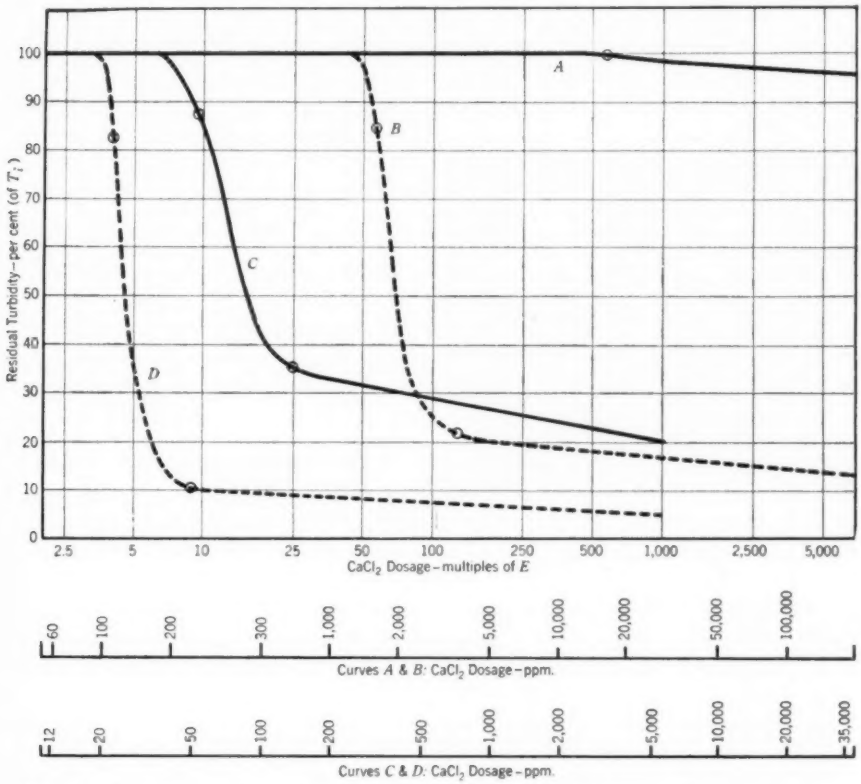

FIG. 4. Perikinetic Flocculation of Medium- and High-Exchange Capacity Waters

might well be expected because of their lack of stability in the presence of ions commonly found in natural waters, the experiments indicate the reason why some water reservoirs become more rapidly silted than others. The curves also explain the apparent paradox that

TABLE 3—*Flocculation With Alum (Series 2 Tests)*

Water Sample No.	Normal or Low-Range Flocculation								High-Range Flocculation				
	Most Efficient Dosage, D_e		Residual Turbidity at D_e ppm.	Final pH at D_e	Min. Dosage ppm.	Max. Dosage ppm.	Final pH		Most Efficient Dosage, D_e		Residual Turbidity at D_e ppm.	Final pH at D_e	Incipient Dosage ppm.
	ppm.	multiples of E					Min. Dosage	Max. Dosage	ppm.	multiples of E			
1A	13	1.17	7	6.95	12	26	7.0	6.6	700	63	30	4.25	410
1B	70*	1.86	10	6.0	50	1,700	4.5		merges with low range				
2A	10	1.17	10	6.9	9.5	20.7	6.9	6.6	500	59	20	4.4	370
2B	70*	2.02	10	6.0	53	1,700	6.5	4.5	merges with low range				
3A	5.4	1.20	20	7.05	4.4	12	7.1	6.7	850	188	90	4.4	480
3B	8.5	1.77	20	7.05	5.4	17.6	7.1	6.8	850	178	60	4.45	530
4A	22	1.18	25	6.7	17	51	6.8	5.8	240		25	4.5	190
4B	92*	1.35	3	5.2	76.5	1,700	5.6	4.3	merges with low range				
5	9.4	4.02	7	7.05	7.8	19	7.1	6.8	no high range				
5A	9.4	5.46	10	7.0	5.95	19	7.15	6.8	no high range				
5B	9.4	5.11	7	7.2	7	20	7.3	6.95	no high range				
6	8.5	3.8	7	7.0	6.3	17	7.05	6.7	no high range				
7A	34	1.55	25	7.2	27	95	7.3	6.4	700	31	40	4.5	290
7B	48*	1.32	35	7.5	37	1,700	7.8	3.5	merges with low range				
8	7	2.28	12	7.1	4.9	12	7.2	6.95	850	285	30	4.4	850
9	21.5	3.06	10	6.9	16	66	7.3	6.1	850	123	18	4.3	370
9A	14	1.96	7	7.3	11	37	7.4	6.7	1,400	196	12	4.4	630
9B	25.5	2.51	7	7.2	20	75	7.25	6.0	500	50	7	4.4	265
10	15	3.13	10	7.2	13	53	7.25	6.1	850	174	18	4.3	710
10A	10	3.87	7	7.35	9.4	29	7.4	6.75	850	323	50	4.3	850
10B	15	5.40	7	7.2	11	59.5	7.4	6.3	850	300	20	4.4	710

* Clarification effected by perikinetic flocculation only.

could be effected equally well with any of the standard hydrolyzing coagulant chemicals and also with HCl or $Ca(OH)_2$. The required dosages, however, were high and averaged in the vicinity of 200 ppm. The pH of the clarified water varied between the extreme limits of 4.0 and 10.0, depending upon the coagulant chosen. The troublesome feature was the excessively large sludge volume and the consequent low water yield of only 65 per cent by volume. Watery flocs and bulky sludges are characteristic features in the flocculation of high-exchange waters. An explanation is that in this type of coagulation the smaller aggregates are threadlike and interlace to form larger network structures which retain the water by capillary action or by simple mechanical occlusion. The appearance of the raw and flocculated San Clemente water is shown in Fig. 5.

Normal Flocculation With Alum

In the Series 2 tests, an added bicarbonate concentration of 0.5 me./l. was selected because this additional alkalinity was found to give optimum or near-optimum conditions for most of the waters tested. That is, with this amount of added alkalinity, good clarification could be obtained and there existed a good balance between the perikinetic and orthokinetic actions for the turbidities employed.* Data from the Series 2 tests are given in Table 3.

An examination of all 21 test curves (not included here) reveals that, as regards alum flocculation behavior in the presence of 0.5 me./l. $NaHCO_3$, the various waters fall into two well defined groups dependent upon whether the exchange capacities are greater or less than approximately 250 μe./l. This point of demarcation is identical to that observed when these waters were flocculated with calcium chloride.

FIG. 5. Raw and Flocculated San Clemente Water

At the higher exchange capacities the waters clarify by perikinetic action alone, in the absence of hydrolysis. At lower exchange capacities clarification occurs first as the normal type of flocculation in which hydrolysis is essential. This statement is illustrated in Fig. 6, which shows standard curves for four levels of exchange capacity: 20, 50, 175 and 250 μe./l.

Considering first the curve for an ordinary water, $E = 50$ μe./l., it is seen that good clarification by normal flocculation occurs over an alum dosage range of from 8.55 to 30 ppm., with D_e equal to 12 ppm. The corresponding

* Under these conditions the clarifications are considered to be the best obtainable solely with alum, and therefore to be a measure of the efficiency of alum flocculation. It was found that the turbidity reductions obtained varied from 85 to 90 per cent, the percentage increasing slightly for more turbid waters, in accordance with the expression:

$$\text{Final turbidity (ppm.)} = \frac{\text{Initial turbidity (ppm.)} + 40}{12}$$

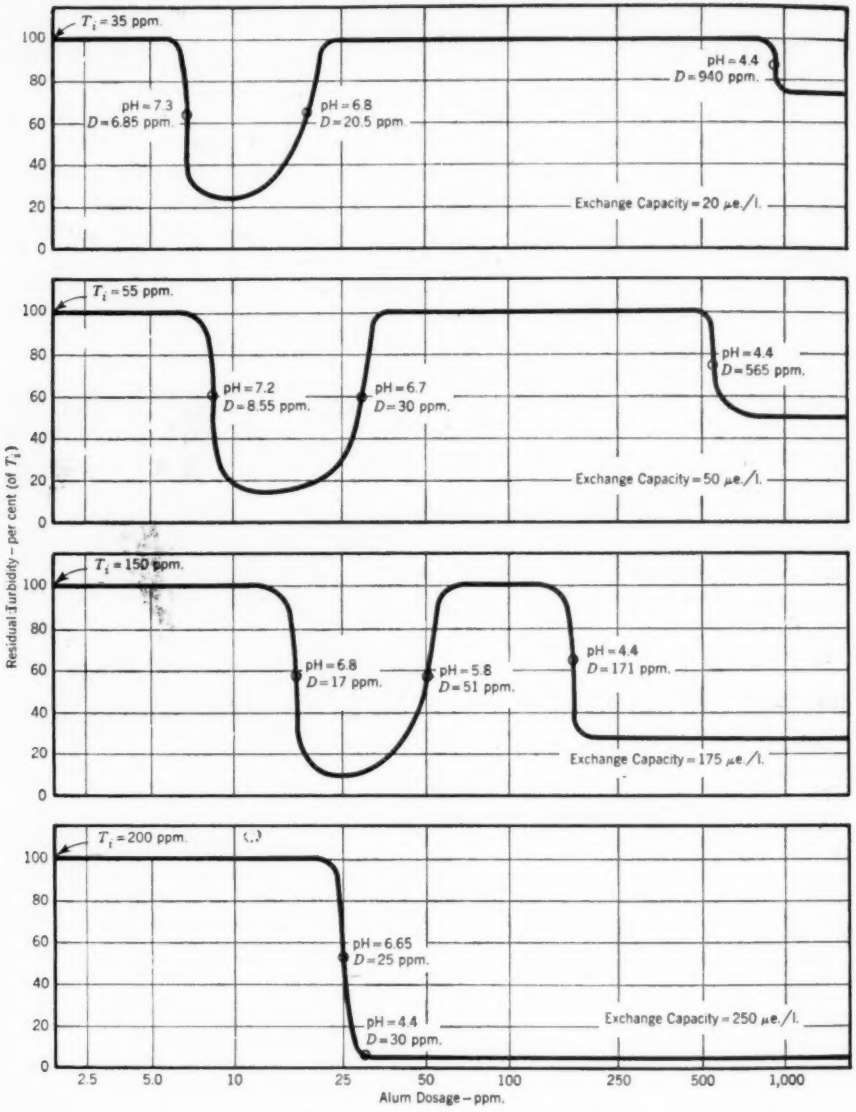

FIG. 6. Effects of Variable Exchange Capacity

pH_f range is 7.2 to 6.7. The higher alum dosages yield negligible clarification until at a dosage of 565 ppm. and a pH_f of 4.4 a secondary clarification zone is indicated. This is the usual curve observed with most turbid waters of low buffer capacity. The normal range of flocculation, as described,

is presumably due to a combination of both perikinetic and binder action by the added alum. The abrupt-drop characteristic of the curve indicates that the perikinetic action must be substantially completed before any hydrolysis occurs. The rise of the curve, ending the normal flocculation range, occurs when so much alum is added that the final pH decreases to about 5.0, the pH below which, for these waters, hydrous aluminum oxide was observed not to exist. The high-range flocculation is evidently due only to perikinetic action by Al^{+++} ions.

The curve for a water of low exchange capacity, $E = 20$ μe./l., is similar to that for $E = 50$ μe./l., but with these differences: [1] for normal alum flocculation, less alum (8.5 ppm.) is required for the most efficient dosage; [2] the range of normal flocculation is decreased; [3] the turbidity reductions effected are smaller; and [4] high-range flocculation begins at a greater dosage (940 ppm.) and effects lower turbidity reductions. The lower dosage required for normal alum flocculation is probably due to a lower perikinetic demand, since, as shown by the Series 4 tests, the exchange alum demand is proportional to the exchange capacity. The shorter range of normal flocculation and lower turbidity reductions may be attributed to the smaller total buffer capacity of the system. The greater alum dosage needed to begin high-range flocculation is explained by reference to the Series 1 tests, in which it was shown that the calcium chloride dosage effecting incipient flocculation, when expressed in multiples of E, increases as E decreases. A similar relationship was found to exist for the dosage of alum needed to produce this action.

The curve for the water of very high exchange capacity, $E = 250$ μe./l., exhibits the results observed in the Series 1 tests. The most effective dosage of alum, 31 ppm., has an associated pH_f value of 4.4, and thereafter the same clarification is effected by larger dosages and there is no rise in the curve. A pH_f value of 6.65 occurs at the midpoint of the abrupt drop. These data indicate that for this water the clarification phenomena occurring at the most efficient dosage and beyond are entirely perikinetic. Only in the region of the abrupt drop could there be any hydrous oxide formed, as indicated by the pH_f values. For waters of even higher exchange capacities, the pH_f values indicate no hydrolysis at all.

In summary, as the exchange capacities of the waters increase, with respect to normal alum flocculation, the required alum dosages increase, better turbidity reductions are obtained and the range of flocculation increases. Also, high-range flocculation is effected by lesser dosages, with increasing turbidity reductions, until, at and above an exchange capacity of 250 μe./l., the high range supersedes the normal range.

Alum Tests (Carbonate Absent)

In the Series 3 tests, no carbonate alkalinity was added. The object here was a study of alum flocculation phenomena in waters of negligible carbonate buffer capacity. The data are included in Table 4.

The various curves obtained with these tests (not included here) were similar to those from Series 2. Generally, the effect of the absence of carbonate alkalinity in the dispersion medium was to reduce the production of hydrous aluminum oxide and to in-

TABLE 4—*Flocculation With Alum (Series 3 and 4 Tests)*

Water Sample No.	Series 3 Tests						Series 4 Tests					
	Most Efficient Dosage, D_e		Residual Turbidity at D_e ppm.	Final pH at D_e	Min. Dosage ppm.	Max. Dosage ppm.	Most Efficient Dosage, D_e		Residual Turbidity ppm.	Final pH at D_e	Incipient Dosage ppm.	Dosage ($T_f = T_e$)† ppm.
	ppm.	multiples of E					ppm.	multiples of E				
1A	13	1.17	20	5.2	12	1,700	7	0.63	15	7.0	3.4	13
1B	50	1.40	10	5.05	44	1,700	0*	0	15	8.4*	0	3.4
2A	10	1.17	15	4.9	9.5	1,700	5	0.58	15	7.0	1.7	10
2B	42.5	1.27	10	4.8	1.9	1,700	0*	0	22		0	3.4
3A	3.4	0.75	80	5.7	2.55	5.95	4.8	1.05	20	7.1	1.7	4.8
3B	5	1.16	80	6.2	4.25	5.95	6.5	1.12	18	7.05	1.7	5.95
4A	25.5*	1.36	12*	4.6*	17*	1,700*	14	0.73	15		0	10
4B	50*	0.75	3	4.9*	44*	1,700*	0*	0	5	8.2*	0	0
5	5	2.20	30	6.55	4.25	5.95	8.5	3.66	12		2.55	
5A	no flocculation						8.5	4.97	10	7.1	5	8.5
5B	5	2.80	20	7.0	4.25	5.95	9.4	5.11	10	7.2	4.6	12
6	no flocculation						7	3.06	15		2.55	
7A	34	1.55	45	7.0	25.5	70	15	0.70	20	7.4	4.25	15
7B	48	1.32	35	7.5	37	1,700	17	0.47	35	7.6	7	17
8	3.4	1.14	25	6.6	2.55	4.25	7	2.28	10	7.1	2.4	6.1
9	17	2.45	10	6.9	14	25.5	10	1.47	10		3.4	10
9A	10	1.47	20	7.1	8.5	15	6.5	0.78	7	7.4	2.0	6.5
9B	20	2.00	7	6.9	1.06	40.1	8.5	0.84	10	7.55	1	10
10	12	2.43	10	7.0	0.57	16	8.5	1.74	10		2.55	8.5
10A	9.7	3.68	15	7.0	7.65	11	8.5	3.22	7	7.35	4.25	8.5
10B	10	3.60	10	7.2	8.5	15	10	3.59	10		5	14

* Clarification effected by perikinetic flocculation only.
† Dosage at which final turbidity equals final turbidity value at most efficient dosage in Series 2 tests (in absence of any added $CaCl_2$).

crease the formation of H^+ and Al^{+++}, at any given alum dosage. Accordingly, smaller alum dosages are required to effect normal alum flocculation, and the range of normal alum flocculation is narrower, with smaller turbidity reductions. Moreover, high-range flocculation is effected with proportionately smaller dosages.

In the absence of carbonate alkalinity the formation of hydrous aluminum oxide is probably dependent upon and limited by the capacity of the turbidity particles to adsorb H^+ ions. Smaller dosages are required to effect normal flocculation because less alum enters into hydrolysis, but the absence of the carbonate buffer severely limits clarification since not enough hydrolysis can occur. Really effective clarification cannot be obtained without the addition of a suitable base.

For the waters of very high exchange capacity, perikinetic flocculation is more easily induced than in the presence of carbonate alkalinity, since less alum is needed to give the necessary concentration of Al^{+++}. The critical value of E, at and above which the perikinetic reactions supplant normal flocculation, is reduced from 250 μe./l. when the carbonate alkalinity equals 0.5 me./l. to 100 μe./l. when the carbonate alkalinity equals zero.

No curves are shown for the Series 3 tests, but, referring to Fig. 6, the curve for $E = 20$ μe./l. approximately illustrates the type of normal flocculation obtained in the absence of a carbonate buffer for a water of 50-μe./l. exchange capacity.

Alum Plus Calcium Chloride

For use in the Series 4 tests, the water samples were prepared with additions of 5 me./l. of calcium chloride and 0.5 me./l. of sodium bicarbonate. The Series 4 data are included in Table 4 and are plotted in Fig. 7.

An examination of the D_b dosages obtained when calcium chloride alone was used as a flocculating agent (Series 1 tests) for settling periods of twelve hours, shows D_b to be almost always less than approximately 5 me./l. Thus, the pre-addition of 5 me./l. of calcium chloride to the turbid waters may be considered as having

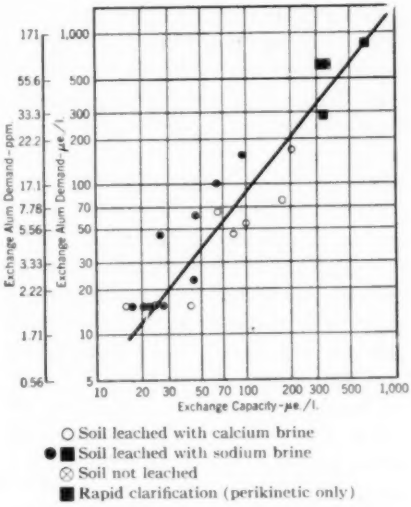

FIG. 7. Relation of Alum Demand to Exchange Capacity

completed the perikinetic flocculation of the system. The principle of mass action suggests that the concentration of Ca^{++} present should prevent any appreciable adsorption of Al^{+++} ions which may be subsequently added to the system as a coagulant. Under these conditions the entire alum dosage might properly be considered as available for conversion into hydrous oxide binder material for effecting rapid agglomeration. Also, the difference between the alum dosages (D_e) required for the Series 2 tests and those for the

Series 4 tests might be considered as equivalent to the exchange demand, or that fraction of the dosages of Series 2 which was utilized for perikinetic destabilization.

Figure 7, as predicted, shows that the exchange alum demand is proportional to the exchange capacity of the system, and, in fact, when expressed in equivalent units closely equals the exchange capacity. For practical purposes, the exchange alum demand may be taken as equal to the exchange capacity. From the Series 1 data, it might be expected that the exchange alum demand would decrease somewhat as the exchange capacity increased, since it was found that the dosage of Ca^{++} ions effecting perikinetic flocculation, expressed in multiples of E, decreases as E increases. The Series 4 data indicate, however, that in normal alum flocculation, in the presence of ordinary concentrations of carbonate alkalinity, visible flocs do not form until after sufficient binder material has been formed, and also that the added alum is not appreciably converted to binder material until the exchange reactions have been completed —that is, until all of the originally adsorbed cations have been replaced with Al^{+++}.

The D_e values determined in the Series 4 tests may be taken as roughly representing the hydrolysis demands for normal alum flocculation. By plotting these values against initial turbidities a fairly linear relationship is obtained, in which the binder alum demand increases very slightly with increased turbidities.* For practically all ordinary waters (turbidities from 10 ppm. to 150 ppm.), the binder alum demand is observed to be from 7 to 10 ppm. when the carbonate alkalinity is of the magnitude of 0.5 me./l. In waters of low buffer capacity, the hydrolysis demand will be related more to buffer capacity than to turbidity, but in such waters the binder produced may be insufficient to effect good clarification.

Summary and Conclusions

A large number of tests of synthetic turbid waters prepared with soils of predetermined character indicate that an important and controlling factor in the clarification process with coagulant chemicals is the cation exchange capacity of the turbidity particles. If this capacity is exceptionally high—250 μe./l. (12.5 ppm. equivalent $CaCO_3$) or more—in the presence of about 25 ppm. of carbonate alkalinity, the water will flocculate readily following prolonged agitation and the addition of any suitable electrolyte yielding active cations, as, for example, Al^{+++}, Fe^{+++}, Ca^{++} or H^+. Normal waters of lower exchange capacities—50 μe./l.—are flocculated efficiently only in the presence of a suitable binder material such as hydrous oxide or basic salt formed by the hydrolysis of alum or ferric coagulants within certain pH limitations. The hydrolysis proceeds only after the soil particles have been substantially saturated or destabilized with cations of the added coagulant. An amount of coagulant proportional to the exchange capacity must be added to furnish the destabilizing cations, and

* That the observed relationship between the hydrolysis demand and initial turbidity is not more precise is probably due to the fact that the alkalinity of each water was not specially adjusted to the absolute optimum value for that water, and to the differences in the nature of the suspended particles for the various waters. When the carbonate alkalinity is 0.5 me./l., the approximate relationship may be expressed by the equation: Binder alum demand (ppm.) = 7 + 0.025 Initial turbidity (ppm.).

more coagulant must be added to furnish the necessary binder material. The destabilizing action conditions the turbidity particles so that they tend to aggregate, and the hydrous oxide, through stirring or other proper agitation of the system, binds the particles together to effect rapid agglomeration and relatively large dense flocs. In order to secure the maximum turbidity reduction with the minimum coagulant dosage, it is necessary that there be a proper balance between the portions of the added alum made available for the exchange and hydrolysis reactions and the actual exchange and hydrolysis demands of the water. Ordinarily, a properly regulated dosage of a single hydrolyzing coagulant is all that is required to bring about proper balance, but, on occasion, more efficient results will be secured by the further addition of a conditioning agent or coagulant aid. Thus, the balance may be affected by modifying the pH of the water, and the pH at which the best balance is attained may properly be termed the "optimum pH" for that water.

The reduction in total alkalinity resulting from the addition of a coagulant cannot be taken as a measure of the amount added or as a measure of the coagulant distribution between exchange adsorption and hydrolysis, because the total alkalinity of the raw water includes an "apparent" alkalinity which is due to the turbidity particles themselves and is absent in the alkalinity of the clarified water.

The addition of either negatively charged sodium-bentonite or activated silica (partially neutralized sodium silicate), by increasing the exchange capacity of the water sufficiently, may decrease the binder or hydrolysis demand to zero. A characteristic feature of this type of flocculation (unaided perikinetic) is the production of large watery flocs and a greater volume of sludge.

Because of the many variables, no simple mathematical formulation of flocculation phenomena is possible, but these may nevertheless be explained through an understanding of the exchange and hydrolysis reactions involved. Proper consideration of these two basic reactions will not only assist in making correct deductions but will serve to explain many of the apparent contradictions which have been reported in flocculation studies and practice.

Acknowledgments

The authors wish to express their appreciation to Russell G. Ludwig, Gordon W. Ludwig and other former students whose thesis studies have made this contribution possible.

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The Public and Water Rate Increases

By John H. Murdoch Jr.

A paper presented on Nov. 5, 1948, at the New Jersey Section Meeting, Atlantic City, N.J., by John H. Murdoch Jr., Vice-Pres. and Counsel, Water Works Service Co., Inc., New York.

HARRY M. Miller, chairman of the Public Utilities Commission of Ohio, recently delivered an address before the U.S. Independent Telephone Assn. which contained statements regarding telephone companies equally applicable to all water works, whether publicly or privately owned. Miller said in part:

> The people . . . are today demanding telephone service of a reasonably high quality. They are merely asking, however, that they be furnished the kind of service which the progressive art of your industry has made possible . . . at a price. Measured by your technical ability, the public demand is altogether fair and reasonable. You have done a splendid job in informing the public what you can do in the way of service, but perhaps not such a convincing job has been done in explaining how it must be done . . . dollars and cents wise. It may be true that the research man in the physical laboratory has done a more thorough job than the manager in the front office. At any rate, our observations convince us that today the public, generally, is not complaining so much about the cost of telephone service as it is about its quantity and quality. In brief, it appears that you have the *ways* to meet the public demand if you had the means. . . .
>
> Another group of companies which have been and are currently providing satisfactory service to their present subscribers are faced with demands from additional subscribers, and with increased usage from present subscribers. Their margins of plant have been exhausted and new capital is required to replace it. Here, again, in many instances, rate structures now in effect were not designed to meet the situation which the demand creates.
>
> In many instances, it is asserted that rates which were designed to meet prewar economic conditions are no longer adequate to meet the situation created by the impact of postwar costs. . . .

These quotations aptly describe the situation in which many water plants now find themselves. Any water works manager whose enterprise is lagging in service or needs new capital to finance the installation of improved or expanding service facilities, and who cannot overcome investor resistance, is faced with the need for increases in rates and has a public relations problem to solve.

That manager's first undertaking should be a complete and careful study of the hard economic facts of his water works and a review of the literature of water works economic theory. The thoughts developed in these studies must next be put to the test of argument with those experienced in water works and general economic practice. Then, with a firm and tested foundation of facts and theories, the manager has the duty of educating and persuading the public. If the preliminary

work has been thorough, the results with the public will be satisfactory.

This paper covers only a general presentation of a case for a rate increase.

Cost of Service

Except when water service is rendered largely at the expense of taxpayers as distinguished from water customers, or at the expense of some other group without adequate compensation, water works revenues must be sufficient to meet the complete cost of service. The phrase "cost of service" has often been misunderstood even by experienced operators, and the misunderstanding has led to embarrassment. The first element in the cost of service includes all operating expenses, such as salaries and wages, materials and supplies, coal or purchased power for pumping, and purification and water treatment chemicals. For privately owned plants, operating expenses also include taxes and depreciation. Most municipally owned water plants are not taxed on their property or on their profits although they do pay hidden, or unconsidered, taxes in wage rates, materials and supplies and all other purchases. Many municipal plants, instead of considering depreciation as an operating expense, make provision for the amortization of the water works debt. It is generally believed that both amortization and depreciation expense should not be charged as a cost of service at the same time.

The second element in cost of service, which is often overlooked, is the annual cost of money or capital. The "annual cost of capital" is the amount of money which must be available, after all operating expenses and amortization charges have been met, to enable the enterprise to pay interest charges and have enough left over to sustain a good credit standing and to attract any new capital needed. If this annual cost of capital is not available through operating revenues, the customers are not meeting the cost of service. Probably most water works enterprises are securing enough operating revenue through rates charged customers to enable them to cover their entire operating expenses, but there are many plants which are today not earning enough to meet the full annual cost of capital. As a result, they cannot secure the funds needed for the type and extent of service which the public is demanding. This was the situation referred to by H. M. Miller.

Annual Cost of Capital

The concept of annual cost of capital must not be confused with the cost of capital additions made annually. To illustrate the distinction, a new purification plant might have a cost of $100,000. That would be the cost of the capital addition. In order to be able to borrow the $100,000 for the new construction, it might be necessary to show the prospective investors that the system has earned and would continue to earn $10,000 yearly over and above all operating expenses and other charges and claims. If such a showing were not made, the money for construction could not be secured. This $10,000 would be the annual cost of capital on that portion of the system represented by the new facilities. In calculating the capital or principal amount of bonds which a given amount of operating revenue would justify, investors in special lien or revenue bonds issued by some municipalities insist on a substantial safety margin. This

margin is part of the annual cost of capital.

The annual cost of capital cannot remain fixed from year to year but varies with the amount of money invested in the property and with the judgment of investors as to the value of that property. It will also vary with the money market and the ever changing ideas of investment experts concerning prudent managerial and accounting practices.

Failure to realize and to give adequate consideration to the impact of this element of cost of service on the ability of the system to function at full strength is the reason some water works plants are in difficulty today.

With relatively few exceptions the water works enterprises, municipal and private, are operating under customer rates fixed before the last war. Some of them are in the position of being able to supply an expanded demand for service through a plant which was previously overbuilt or with large excess capacity. The growth of business has brought increased revenue without the necessity for additional plant and is more than sufficient to cover increases in operating expenses. Such plants will probably soon reach the stage of development which is now more typical, where all excess capacity has been used up and where demands for service already exceed safe plant yields and the carrying ability of the distribution system.

Since this is believed to be the more usual situation, it is worth looking at the trend of the cost of service and its effect on such a system.

There is no need to labor the record with a recital of detailed costs today compared with those of earlier years. Investigations of such cost trends have been made and published by engineers thoroughly qualified to make the studies and to interpret them. What the present writer wishes to bring out is that an increasing proportion of operating revenue is now being used up in operating expenses, with the consequent lessening of the proportion contributing to the carrying of the annual cost of capital.

A group of water companies in New Jersey in 1934 had an operating ratio —operating expenses divided by operating revenue—of 54.5 per cent. In other words, in that year 45½¢ out of every dollar of revenue was saved and contributed toward the annual cost of capital. In 1941 the operating ratio was up to 64.5 per cent, and in 1947 it was 71.0. The operating ratio worsened in spite of increased business and some upward rate adjustments, and in 1947 the amount available from revenue for the annual cost of capital was only 29¢ out of each dollar, compared with 45½¢ in 1934. For a much larger and widely scattered group of water companies, the operating ratio rose from 50.2 per cent in 1934 to 67.4 in 1947.

Turning now to the annual cost of capital, interest rates on borrowed money are slowly rising. Preferred stocks are not popular and often can be distributed on the market or to institutional investors only if some sinking-fund provision is made. There appears to be a tendency to look critically at the number of times interest or preferred dividends are earned and to demand high rates if the margin of safety is not considered large enough. Investors in equity securities, especially common stocks, in view of the income tax situation and general market conditions, are rather few and insist on attractive yields. All of this adds up to a high cost of capital. Moreover,

these high-priced dollars do not buy anything like what they used to buy, so that more of them are needed to accomplish a desired end. In prewar days, 1 ft. of 6-in. cement-lined cast-iron pipe cost approximately $1.50 laid; today the price exceeds $3.35. Previously a service line and meter, installed, cost about $35, while today the comparable cost is $66.41.

Most plants at present appear to have reached the saturation point on customers per mile of main. For one large group of water companies, there are 80 customers per mile of main, a figure which has become stationary. This situation is to be expected, considering the common desire to build and live in outlying real estate developments. Whatever the cause, it seems to be the fact that, on the average, a water works system must lay about 70 ft. of pipe for each new customer. Thus, assuming an average pipe size of 6 in., each new customer imposes a capital expenditure for pipe, service and meter only of $300.81. If supply and transmission works are considered in addition to distribution facilities, it is calculated that each customer now costs more than $400. With rates fixed on the basis of prewar costs and with operating ratios now ranging up to 70 per cent in well managed plants, it becomes clear that each new customer is a burden very difficult to carry.

This statement can be verified by calculation. If the operating ratio of the plant is 70 per cent, each dollar of revenue contributes only 30¢ to the annual cost of capital, which includes the amount needed to cover not only distribution but also supply facilities. If it is assumed that distribution facilities represent half the cost of the entire system—a condition which is very common—then half of the annual cost of capital must be assigned to the distribution system and half to the supply system. In the present illustration, therefore, only 15¢ of the revenue dollar is available for the annual cost of capital in distribution facilities. For privately owned plants, as of November 1948, the true annual cost of capital is certainly not less than 6¢ on each dollar of investment. For municipal plants, the comparable figure is somewhat lower, and it will be assumed as 3¢ on the dollar. Because of the tax situation, the operating ratio of municipal plants is probably in the neighborhood of 50 per cent.

To find how much investment can be made in pipeline and service connections for each dollar of new revenue, let A equal annual revenue; b equal the operating ratio; C equal the ratio of supply facilities to all facilities; and R equal the annual cost of capital expressed in cents per dollar of investment. The formula will be:

$$X = \frac{(A - Ab)\ C}{\mathrm{R}}$$

Substituting 1 for A, 0.70 for b, 0.50 for C and 0.06 for R, X would equal $2.50. According to this formula, then, the enterprise can afford to invest $2.50 in lines and meters for each dollar of new revenue. As most domestic customers today pay on the average only about $15.00 a year, the system can only afford to invest $37.50 for an average customer, while it costs about $300 to attach that customer. For a municipal plant with its lower operating ratio—traceable to the tax differential and the lower annual cost of capital—the application of the formula indicates that such a plant could invest $8.33 in distribution facilities for each dollar of new revenue,

or a total of about $125 for a new domestic customer paying $15.00 a year for service. Ignoring the element of annual cost of capital on supply facilities and calculating the amount of revenue remaining available for annual cost of capital after income taxes, private plants could invest $75 in distribution facilities for the average domestic customer. If supply works are ignored in a study of a municipal system, approximately $16.00 per dollar of new revenue would be the proper investment in distribution facilities, or about $250 per average new customer. Thus, it seems almost any method of calculation shows that each new domestic customer requires more investment in distribution facilities than is justified by the existing rates. This is an undesirable situation from the standpoint of the public.

Conclusion

At the very time when the cost of service is advancing, the customers and the public are eager for improved and extended service. The population is growing, but it is not tending to build up in the older sections of communities. As business moves in or blight strikes a neighborhood, the established trend is for movement into outlying newly developed territory. This entails, for the water works, more operating expense, more capital investment at peak unit costs and a greatly expanded annual cost of capital. There is a demand for more uniform and constant quantities and pressures, requiring enlarged distribution facilities and often distribution storage. There is a growing demand for softened water. The per capita water pumpage is rising in well maintained and operated plants, which means that more plants tend to use up their available capacity and come to a realization of the need for new supply works. All this again adds up to an increased cost of service which the public must be brought to understand.

More and better service is a public demand. Water works technicians know how to design and operate the plants which will put completely adequate amounts of good-quality water into the system and deliver it to the consumers. The only drawback is the lack of money. It cannot usually be secured at existing rates because the present cost of service is completely out of line with revenues based on cost figures which are of antiquarian interest and nothing more.

The American people—the water customers—are fair-minded and want to pay their own way. They are capable of understanding these problems and of realizing how their interests harmonize with those of the water systems. All that is needed is a patient educational program carried on by water works men who understand and can explain their own business and its difficulties. When such men step forward, become vocal and evangelize first one or two leaders and then ever widening groups, the public relations aspect of water rate increases will be most pleasant.

Maintenance of Zeolite Filters

By Perkins Boynton and Henry Gay

A paper presented on Oct. 3, 1947, at the West Virginia Section Meeting, Bluefield, W.Va., by Perkins Boynton, Chief Chemist, and Henry Gay, Asst. Chemist, Clarksburg Water Board, Clarksburg, W.Va.

EARLY in 1939 the Clarksburg, W.Va., Water Board installed three additional rapid sand filters and four zeolite natural greensand softeners. From the start these softeners gave excellent results. They are each 15 ft. square, with 66 in. of greensand, and are rated at 1 mgd. but are set to deliver from 700,000 to 800,000 gpd.

The water applied to the softeners comes from the clear well after passing through the sand filters. The zeolite is guaranteed to remove 2,800 gr. of hardness per cubic foot, and the length of the runs depends on the hardness of the applied water. The average run ranges from fourteen to 24 hours.

Loss of Greensand

After the softeners had been in use intermittently for three years, it was found that the original depth of the greensand had diminished greatly, the loss varying from 1 to 2 ft. in each of the four softeners. It appeared certain that the loss had not occurred in the washing of the filters, but examination of the creek into which the wasted water ran showed large accumulations of the greensand, as also did the clear well. It was surmised that zeolite had been washing away through the supporting gravel and the underdrains. The zeolite in the creek had been washed there during the period of flushing that takes place each time the softeners are regenerated. After greensand and gravel were removed from the beds, the underdrains were examined and found to be in place and in good condition. The reason for the loss of greensand appeared to be that the upper layer of fine gravel supporting the sand was not fine enough, although of $\frac{3}{16}$-in. size.

A layer of so-called torpedo gravel, 0.8 to 1.0 mm. in size, was placed in each softener to a depth of 3 in. The greensand was replaced, that from the clear well was recovered, and new greensand was added as needed to restore the original depth. As an additional precaution against loss, the initial flow of wash water was cut in half until the water was washing freely through the beds, when the flow was stepped up to its original volume. Since that time no appreciable loss of greensand has occurred.

The usual practice when the water in the river did not require softening was to leave the zeolite beds idle with the water in them slightly over the top of the sand to prevent dust and coal cinders from accumulating on the surface of the greensand.

Combating Microorganisms

When the softeners were put into operation in 1947, an unusual thing occurred. The rate of flow of the filters

would start out at near normal (700,000 to 800,000 gpd.), but would soon drop rapidly until they were filtering at a rate of only about 100,000 gpd. The filters were allowed to run the usual number of hours, or until the effluent was hard, but with inexplicable slowness. Those in charge of operation were puzzled about what was clogging the filters. At first air was thought to be in the sand, but that seemed impossible after washing as usual. Closer examination showed the presence on the grains of greensand of amorphous matter, the growth of which had been aided by a plentiful supply of light from windows facing south. The chemists first tried applying a large quantity of saturated salt brine, since this was readily available, but with no success. Then, using their knowledge of the treatment of microorganisms in basins and filters, they tried copper sulfate in as strong doses as they dared, but still to no avail.

Finally one of the chemists realized that moisture was beneficial to organisms, whereas dryness and the absence of light were prejudicial to their growth. Light and sunshine could not be excluded, but the water could be drawn off. This was done by leaving the filtered-waste valves open, accomplishing a complete drying of the whole bed in each filter. After being allowed to stand this way for several days, the filters were washed and the next runs were normal. Now, when the softeners are not in operation, they are allowed to stand dry.

Bo Brown—*Christian Science Monitor*

"Pop, Is 'Waterworks' One Word or Is There a Hydrant in the Middle?"

Diagnosing Water System Defects

By R. D. McGill

A paper presented on Oct. 8, 1948, at the Ohio Section Meeting, Mansfield, Ohio, by R. D. McGill, Engr.-Repr., The H. C. Nutting Co., Carey, Ohio.

THERE appears to be a certain analogy between the human body and a modern community. The one has a nervous system; the other, its telephone, light, power and signal systems; the one has a digestive and intestinal tract; the other, its sewers and waste disposal plants; the one, a heart circulating blood through arteries and veins; the other, its water plant pumping water through mains and service lines. Further similarities could be presented, but enough have been given to demonstrate that, just as the human body requires the services of a doctor from time to time to correct ailments or to prescribe preventive measures, so will the modern community occasionally require the services of a skilled practitioner to correct evils, plan improvements and outline safeguards for the existing plant. This analogy is probably more applicable to the water department than to any other division of the community.

Buildings, streets and bridges are visible to everybody and more or less become everybody's business. But the water system, with so much of its plant underground, unseen and unknown, is like the heart and the blood stream—unthought of until something serious takes place. The patient has often been ailing for years and could have enjoyed almost perfect health had he—or it—undergone a thorough physical examination and heeded the warnings of the practitioner.

With these thoughts in mind, the author was not surprised when a water distribution engineer remarked one morning last winter: "You know, this is just like a country doctor's office. Whenever one of the smaller water works hereabouts gets into real distribution trouble it calls upon us; we diagnose the case and prescribe the remedy."

Asked what the trouble was with his latest patient, he promptly replied, "Hemophilia." And this was the story:

During the extreme cold spell in the winter of 1947–48 the Ohio River froze over. To prevent ice jams as much as possible, the wickets of the dams were dropped, which, in turn, dropped the elevation of the water below the level maintained as normal pool stage. Some of the wells along the river bank were affected by this drop in head—among them, the one at Augusta, Ky. Thinking that the screen had become plugged up, the authorities called in a well driller to clean up the well. Pumping was then resumed, but the pressure could not be maintained in the system. Finally, in desperation, to provide at least for fire protection, a pump was installed on the river bank at the only point not frozen over, the outlet of a sewer. When

pumping was again started, however, there was still no pressure throughout the system. Then the thought came to somebody that possibly a large leak was causing the difficulty. By the manipulation of valves and continued pumping, the trouble was finally located at an important intersection in the business district. The area was paved with good concrete, and there was nothing but sledges and moil points available for breaking through. Nobody had the courage to start the excavation without assurance that the leak would be uncovered. And so the country doctor was called in. He made the necessary examination and fixed the place for the operation, which turned out successfully, with the patient enjoying a normal life today.

Causes of Water Loss

Having introduced the country doctor, it may be worth while to continue the analogy, looking into some of the diseases affecting the circulatory system of the human body and comparing them with the ailments of a water distribution system.

Anemia is a deficiency or low condition of the blood. Normally an ailment of this nature would pertain to the supply rather than the distribution system. Frequently, however, an anemic condition exists in areas of the distribution system primarily by reason of ailments other than a lack of supply at the source. These ailments will be the subject of the present discussion.

One of the rare diseases of the human body is hemophilia, the tendency to abnormal bleeding. The tendency to abnormal leakage, however, is a common ailment of water distribution systems. As a rule, nothing is done about it until a serious problem is involved, in spite of the fact that a few calculations and a comparison of existing records would have provided the warning without any outside aid or advice.

Practically all water works have some fairly accurate method of determining the amount of water produced —either by master meters or through a knowledge of pump ratings with a record of the time the pumps are operated. A comparison of these figures with the total of metered sales for a given period will readily demonstrate whether the system is suffering from hemophilia. If 90 to 95 per cent of the water is accounted for, the system is in excellent health; if 80 to 90 per cent is accounted for, there is no need to worry, but it will be advisable to keep on the alert. If less than 80 per cent is accounted for, the seriousness of the problem is in direct ratio to the percentage of the water unaccounted for.

Should the system not be 100 per cent metered, an accounted-for figure can be established by striking an average of the metered sales and applying it to each unmetered unit. When a system is entirely unmetered, a figure of 35 gpd. per capita can be assumed if a residential area is being served and 100 gpd. per capita if the system is serving a large quantity to industrial users. Some judgment naturally will have to be exercised in computing legitimate usage on the latter basis.

To be positive of the actual condition, it is necessary occasionally to check the performance of the master meters and pumps. This check will generally require outside assistance, especially in the smaller plants, which are usually not so well provided with special equipment as some of the larger ones.

Another way of determining the symptoms of hemophilia is to study the night rate of consumption between the hours of 1:00 and 5:00 A.M.—not what *may* be pumped during those hours, but what is actually consumed. Measurements, therefore, have to be made of the decrease or increase in storage that may accrue. Sometimes, when the system is supplied entirely from storage during this period, the drop in pressure can be noted to determine if anything abnormal is taking place. Unless there is high industrial usage, the consumption during the period mentioned should not be at a higher rate than 25 to 30 per cent of the average daily use.

After the symptoms have been diagnosed and the conclusion has been reached that the system is suffering from hemophilia, there are many remedies which can be adopted, but, in the long run, it is better to call in a practitioner who is fully equipped and experienced. No two cases are ever identical. Even though the symptoms all point to hemophilia, the actual disease may be something else. Despite the fact that the record indicates a sizable loss of water, the loss may not be due to leakage. The immediate problem is accounting for the "unac."*

If one is positive that the trouble is hemophilia or excessive leakage, the corrective measure is to locate and repair the leaks. If a leak appears on the surface, like a cut or external injury to the human body, it can usually be promptly bandaged and an immediate cure effected. Unfortunately, not all leaks are superficial, and internal disorders are not so readily ascertained. Just as a doctor uses a stethoscope to diagnose internal conditions, so can a man experienced in the use of leak detectors, geophones and aquaphones determine the location of many underground leaks, particularly if the hemophilia is caused by angiomalacia (softening of the blood vessel walls) or angiorrhexis (ruptured blood vessel)—that is, if the leakage is due to the deterioration of service lines through excessive corrosion or to the rupture of a main line caused by a cracked pipe or a blown joint. If the patient is suffering from hermatorrhea, however, there is a possibility that the sound amplification instruments may not detect the loss, for this disease, consisting of bloody discharges through the bowels, means that a volume of water is being discharged through the sewers. Under certain conditions, this flow may directly enter a sewer through a smooth, unrestricted channel—such as washout lines from a reservoir or blowoffs with the valve wide open—and only slight, if any, vibrations are set up. Consequently, it is felt that the best way to combat hemophilia of the water distribution system is to make a water waste survey through the medium of flow measurements.

* Unaccounted-for water.

Water Waste Surveys

A complete water waste survey is similar to a physical examination of the human body and, like the latter, may uncover many an unexpected ailment. The very nature of the survey requires such an encompassing investigation that in reality it becomes a diagnosis of the water distribution system and often reveals maladies far more serious than the hemophilia which was first suspected.

For instance, "valvitis" may be discovered—that is, trouble with the valves. All water systems are more

or less affected by this disease. As long as it consists merely of difficulty in operating valves, it is of no serious consequence, except when it is desirable or necessary to close the valves in order to make repairs or connections. But if valvitis reaches the proportions of complete stoppage of the principal arteries, or arterial mains, serious results can take place, especially during large fires, when every drop of water normally available is needed. Water distribution systems have been found in which all the arterial mains were closed by one or more valves somewhere along their routes, thus forcing the water to circulate entirely through 4- and 6-in. mains instead of being fed by the arterial system. Imagine trying to keep the body in a healthy condition by circulating blood through the veins alone!

A complete water waste survey, or diagnosis of the water distribution system, will also uncover focal points of infection—the cross connections between public and private water supplies. Every such cross connection, unless made and guarded in accordance with regulations of the state department of health, is a potential point of contamination that may infect the blood stream of the community and cause an epidemic among the water consumers.

To complete the physical examination, especially if anemic conditions continue to exist, it is advisable to look for arteriosclerosis (abnormal thickening and hardening of the walls of the arteries with age)—that is, the reduction of carrying capacity of the arterial mains by tuberculation due to age. This condition can readily be determined by loss-of-head tests and by calculating the frictional losses.

At the same time the condition of the circulatory system should be investigated by the measurement of flows and the recording of pressures along the arterial mains. The veinous part of the system—the intermediate grids—can be examined for carrying capacity by running fire flow tests.

Thus, a complete physical examination of a distribution system would be effected, providing for a diagnosis of its ailments and making possible an economically sound prescription to remedy the ills. The benefits to be derived from such an examination and diagnosis are self-evident. They include:

1. A decrease in pumpage, once the leaks are repaired, resulting in a reduction in operating costs, which will run at least 2¢ per thousand gallons where water is treated. Frequently the cost is much greater, especially when zeolite softening is utilized.
2. An increase in revenue, where unauthorized usage or serious underregistration of meters is detected.
3. Knowledge of the condition and operating characteristics of all valves.
4. Information bringing the distribution map up to date as well as all the data on flows, pressures and main conditions necessary for intelligently and economically planning improvements and extensions.

Case Histories

A few case histories will illustrate some of the advantages derived from water waste surveys.

Case A. In a small suburban residential community of 1,500 population, consumption had been averaging 54,000 gpd. but suddenly increased to 74,000. A survey was made which, in the opinion of the client, "was a great success. We have opened the

streets and made the necessary repairs, and the results are really showing in less pumping and more pressure."

As 20,000 gpd. is not much water to be looking for, it was surprising that this client was so anxious to have a survey, which, considering the results obtainable, would be rather expensive. The answer was that this community was dependent upon wells and springs producing only from 30 to 50 gpm. each. A continued consumption of 74,000 gpd. would have necessitated the drilling of another 650-ft. well, from which the production would be questionable. The discovery of two underground leaks and one minor source of leakage by the survey saved several thousand dollars in new construction plus $390 a year in increased pumping.

Case B. The source of water supply for a certain community of 6,000 population is a 40-mil.gal. mountain reservoir located at such an elevation as to permit distribution by gravity. No treatment other than a slight amount of chlorine is required.

Apparently there was not much cause to worry about leakage, since under normal conditions plenty of water was available and no power or chemical costs were involved. In fact, the city felt no concern except during a couple of short dry seasons when it was deemed advisable to purchase some water from a private supply rather than to chance complete depletion of the reservoir. Even then, the bill only ran to a few hundred dollars. But, as in most communities, the chamber of commerce was ambitious toward industrial expansion. A small industry was interested, partially on account of the quality of the local water. When the demand was determined, however, the city realized that it could not supply it, yet it seemed that with normal consumption it should be able to do so. After considerable local investigation, it was finally decided to make a water waste survey.

The survey showed the total consumption to be 707,000 gpd. with a minimum night rate of 585,000 gpd., or 83 per cent of the total. Of the total consumption, 73 per cent was unaccounted for. Sixty-one per cent, or 430,000 gpd., was found to be leakage, one blowoff accounting for 185,000 gpd.

The city is again looking for an industry such as it lost because of the previous water supply deficiency.

Case C. In a city of 11,000 population, an average community of that size, the water is obtained from eight wells and delivered to the distribution system through five small treatment plants. The business district lies in a valley and the better residential areas are on surrounding higher elevations.

The wells were producing an unknown, apparently inadequate, supply of water. The pressure was dropped at night to such an extent that the residential areas had no water. In the summer this operation was occasionally also performed during the hours of 1:00 to 5:00 P.M. so that the 200,000-gal. tank at the central station could be filled. It was necessary to fill the tank in order to have an ample supply available for the following day, since the wells were not producing sufficient water for continuously supplying the entire city.

Engineers had planned the development of a surface supply from a nearby river at a cost of somewhat over $1,000,000, but bonding companies were opposed to the financing. Caught in the dilemma of no water and no

money, somebody conceived the idea of a water waste survey.

The survey revealed that the average daily pumpage was 755,000 gpd.; the minimum night rate was 51 per cent of the total, with 99 per cent of it leakage; 58 underground leaks were detected and, by the time eighteen of them had been repaired, a continuous 24-hour supply was afforded the entire city with two of the wells shut down during the greater part of the night. The ultimate saving after the repair of all leakage was $4,039 a year for power and chemicals.

It was not this saving, however, but the possibility of increased revenue that influenced the bonding companies to renew their interest in financing the new development (which is still vitally needed for the healthy growth of the city). With more water available for legitimate usage, sales were bound to go up, since the restrictions previously placed on sprinkling, car washing, and commercial and industrial use could be lifted. In the meantime, while work on the new supply goes on, the city is enjoying full usage of water.

Case D. A city of over 100,000 population requires a raw-water delivery to its filter plant of at least 15 mgd. through 3 miles of dual cast-iron pipelines, one 24 and the other 30 in. in diameter. Difficulty was experienced in securing adequate delivery to handle peak loads.

As the 30-in. line was comparatively new, loss-of-head tests were run on the 24-in. pipe, revealing that it had a carrying capacity equaling that of a line only 19 in. in diameter. Cleaning and relining restored this pipe to its full carrying capacity and resulted in a considerable saving, as against the construction of a new line. Tests before cleaning definitely demonstrated the need for developing more carrying capacity, while the tests afterward assured the city that it had regained the desired capacity, equal to that of a new 24-in. pipe.

Many other cases could be presented to show how positive data regarding flows, pressures and the like have guided those responsible for the physical condition of distribution systems in planning an economically sound improvement program.

Conclusion

No attempt has been made to present a technical discussion but rather to point out the similarity between the human circulatory system and a water distribution system, along with the diseases common to both. Just as a yearly physical examination will reveal latent maladies, so will a periodic checkup of the water distribution system expose its existing faults and deficiencies. In both instances, the examination will permit the prescription of remedial measures and afford an opportunity to inaugurate a restorative program. Vital statistics prove the soundness of the annual physical examinations, and the results of water waste surveys and distribution studies have always demonstrated the value of such investigations by increased revenues and money accrued, either through the reduction of operating costs or through savings in new construction.

Furnishing Equipment to Employees

By Duncan A. Blackburn

A paper presented on Oct. 29, 1948, at the California Section Meeting, Riverside, Calif., by Duncan A. Blackburn, Prin. Engr., Pasadena Water Dept., Pasadena, Calif.

EVERY public utility furnishes some equipment to its employees, ranging from almost nothing to quite a broad list of items. It is disappointing that very few utilities can point to any concrete results from this service to the employees, but, in the author's opinion, many valuable benefits are obtained, although quite a few may be intangible. In approaching this subject it is necessary to review and classify the equipment supplied to water works personnel.

Classification of Equipment

The equipment furnished for the use of the employees can be broken down into three broad classifications, according to function:

1. *Appearance*—uniforms, vehicles
2. *Health and safety*—rubber boots, raincoats, rain hats, gloves of all kinds, goggles, eye shields, hard hats, welding aprons, safety shoes, first-aid equipment, respirators, towel service
3. *Efficiency*—Tools, mechanical equipment, drafting machines and all other large drafting tools; pens, pencils and stationery supplies; technical books and magazines, desk lamps, proper equipment for vehicles.

Some utilities supply almost all of the above items, whereas others supply only a few. This paper will not attempt to comment on the entire list, but only on those with which the Pasadena Water Dept. has had the broadest experience.

The Pasadena Water Dept. has for years supplied tools and some wearing apparel to its construction employees. In 1943 uniforms and a number of other items were included in the list. During 1947 several pieces of drafting equipment were added to those already furnished in the engineering office.

It can be said substantially that if a field employee walks to the gate of the construction yard in his underwear and shoes the water department will outfit him from there on. No water department employee is required as a condition of his work to provide any tools whatsoever in any classification, except that engineering employees are required to furnish their own drafting sets. If the utilities, by furnishing any of the previously mentioned equipment, are to improve the appearance, promote the health and safety or increase the efficiency of their personnel, there are several rules which should be followed. Personal wearing apparel should be adequately cleaned and maintained and should be issued in sufficient quantity so that it is not used by more than one employee unless it is sterilized. Tools and mechanical equipment should be well sharpened and maintained, and employees should be schooled not to waste or misuse them.

Costs and Maintenance

The cost of supplying uniforms, which have the name "Pasadena Wa-

ter Department" over the breast pocket of the shirt in letters ½ in. high, to construction employees is approximately 7½¢ per man-day under the present expanded price conditions. This cost includes four sets of trousers and shirts. While one set is being worn, another is being laundered, one is ready to be laundered and one set is available for the employee to change into in an emergency. Each employee is furnished two clean uniforms a week. The laundering of these uniforms—by the washing and mangling process, which gives a presentable rough-wash job—is done at the water department's expense and approximates 6¢ per man-day. Any necessary repairs to the uniforms are made by the men themselves.

The total uniform cost is not a large item, as it represents slightly more than 1 per cent of the employee payroll for those issued uniforms.

Not all water utilities supplying uniforms have the same procedure as outlined above. Some require the employees to furnish their own uniforms while the companies will maintain and clean them; others assume 50 per cent of the first cost and pay for the maintenance and cleaning; and some utilities will bear none of the cost. The cost of other articles of clothing and shower towel service for the Pasadena Water Dept. during the past fiscal year was $2,475. This figure includes raincoats, rain hats, rubber boots, gloves of all kinds, towel rental, and coveralls for the men in the garage. When broken down the average cost per man-year of $33.45 does not seem excessive, for it represents the ability to require men to work under any inclement weather conditions when necessary and under the wet conditions which are normal for any water department. The cost of small tools, which includes any with a value of $25 or less—such as tarpaulins, water hose, lanterns, flashlights and other miscellaneous articles not chargeable to a job order—amounted to $3,665 for the past fiscal year, or approximately $49.10 per man. The cost of repairing small tools, including the replacement of lantern globes, was $2,985, or approximately $40.30 per man for the same period. This small-tool cost, when considered in the light of inevitable loss or replacement of such articles, is little enough to insure that every man at all times has the proper tools in good repair to work with on any job to which he is assigned. For example, if he furnished his own tools, an employee could not be assigned to work in an emergency not in his line.

Employee Relations

One of the reasons why the Pasadena Water Dept. established the policy of supplying equipment to its employees was to build morale. The objective of any organization should be high morale and good teamwork, but too little emphasis has been laid on these factors by many companies. Maintaining employee morale at a high level will tend to prevent resentment and grievances. Furnishing a uniform of any kind lends dignity to the work. Workmen have a natural pride in the tools of their craft and if good tools are provided them they will do a better grade of work than if equipped with makeshift tools. Proper equipment can prevent accidents hazardous to both employees and the public. Any of the items furnished for protecting the employee against injury or accident are to his benefit financially because the time lost from work is decreased. If supplying safety equipment is left to the employee he might, because of the financial burden, decide

to do without it. The furnishing of equipment for the employee's comfort, such as heavy raincoats for wear in stormy weather, makes the worker realize that the management understands the unfavorable conditions under which he must sometimes labor and gives him pride in the organization which feels such concern for him.

The placing of showers, together with towel service, at the disposal of the employees must not be overlooked, as the men coming in from a job that is rarely ever clean appreciate an opportunity to bathe before going home.

Many employees have had some of these services so long that they have forgotten the definite advantage accruing to them. This fact was brought out during World War II, when many items were in short supply and could not be obtained in sufficient quantity. For example, a simple item such as cheap canvas gloves was sorely missed.

It should also be noted that supplying clothes and tools to the employee relieves him of this expense. He actually obtains an advantage in dollars which, when added to his salary, will make it more nearly approach the higher wages in industry today.

Public Relations

Uniforms and shirts identifying the department give the employee a more presentable appearance and inspire public confidence. An employee with paint-spattered overalls and a greasy hat is not considered a correct representative from the aesthetic point of view, which any water department should consider in its public relations. The man in uniform has at least the appearance of being more official, when required by his work to contact the public, than the man in nondescript clothes. It is the author's opinion that a uniform actually is received more readily by the public than is a badge or other identification. This statement is borne out in discussing the subject with the employees.

Proper and standard equipment means more efficient service to the public, which is more observant than many utilities believe. People may not always comment favorably when watching workmen handle a job of construction or repair efficiently with good tools and equipment, but if there is anything wrong the department will hear about it later. The use of safety equipment protects the public as well as the employee. The utilities should always carry on their work with the safety of the public in mind.

It must not be forgotten that the utility's relation with the employee is a most important factor, as his sphere of immediate influence includes his friends, neighbors and relatives and the portion of the general public with which he comes in contact. If he takes satisfaction in his job and pride in the utility his attitude can become a force that is constantly building goodwill in the public mind for the organization of which he is a part. If, on the other hand, he is indifferent or disgruntled, an unfavorable impression even more powerful in its effects will be created.

Conclusion

The utility reaps a great benefit from an adequate program of furnishing good equipment to its employees. Labor costs have risen to such an extent in the last few years that efficiency must be increased to keep the expense of finished work as low as possible. For example, a draftsman today gets as much as the chief engineer did twenty years ago. A good illustration of increased efficiency is the work of cutting into a main under pressure, which formerly took two men three

hours to do and now, with the use of an air motor, takes two men 30 minutes. Any contribution to the employee's safety and health will produce an increase in efficiency and will thus be of value to the utility. If the accident rate is low, there is bound to be a favorable reflection in the insurance costs.

The author believes that, when the above equipment is supplied, the employee must be made responsible for it and must be schooled in its proper use and care. Otherwise, the cost of this service will become too high and some portion of it will have to be dropped. The employee should always remember that there is a tool for every job and he should use the correct one. If this rule is not followed and the tools are abused, their life will be shortened. Some type of informative program should be constantly carried on to keep the employees familiar with the proper use and care of equipment furnished by the utility.

Maintenance and Testing of Meters

By W. T. Rimele

Abstract of paper presented Nov. 19, 1948, at Florida Section Meeting, Panama City, Fla., by W. T. Rimele, Meter Foreman, West Palm Beach, Fla., Water Co.

At West Palm Beach meters are tested at following flows:

Disc Size *in.*	Full Flow (approx.) *gpm.*	Low Flow *gpm.*
⅝	12	¼
¾	20	½
1	30	¾
1½	60	1
2	90	1

On full flows meters are adjusted within 2% of complete accuracy. Although rates drawn usually higher than ¼ or ½ gpm., low flows may be caused by leaks or other conditions. Low-flow sensitivity is affected by temperature of surroundings. A meter which registers 85% on the test bench has enough disc clearance to allow for thermal expansion, but one registering 95% may not have. A meter may underregister if the control block is worn, permitting the disc to go toward the center. The top casing must be screwed down tightly. If there is slight friction in the disc, scouring powder in water will usually make it run smoothly after a few turns; otherwise, it should be taken out and spots shown by powder scraped. Meters are field tested every 5 years, although the amount and quality of water measured really determine their condition. Crest and compound meters are tested once in 18 months. A meter is also checked when a marked drop in water consumption is noted by the billing clerk. Meters can be tested in or out of service with apparatus consisting of 1-cu.ft. container tapered at top and 2 hoses, one from service to meter; other hose has low-flow test device made up of pressure gage, needle valve and tip of welding torch with ⅛-in. bore. In addition to saving time, this method reassures customer watching test of registration accuracy. In testing large disc meters, the chamber is replaced. Results of the test and repair parts used are noted on the meter card. For compound-meter test, disc section is replaced by device which keeps water from house line and has 2-in. outlet for connecting test meter. In testing crest meters, cage is replaced by tested one.

The Selection and Care of Water Meters

By Charles Bachmann

A paper presented on April 23, 1948, at the Indiana Section Meeting, Lafayette, Ind., by Charles Bachmann, Factory Engr., Neptune Meter Co., Long Island City, N.Y.

IN bygone days it was necessary to convince various water works officials and other responsible authorities that universal metering was the really equitable and practical method of accounting for the vast quantities of water distributed to the consuming public. Today, however, the situation is quite different, and the widespread recognition of the merits of metering has brought with it the problem of selecting the proper types and sizes of meters, together with the all-important matter of the care and attention necessary to guarantee a reasonable performance on the part of the great number of meters now faithfully serving the water works industry.

Meter Types

The two fundamental types of water meters are the positive-displacement meter and the current meter. Both may be utilized in different combinations to produce proportional meters, compound meters and other so-called "types," but actually the essential measuring action is based directly on either the positive-displacement or the current meter principle, or both. It may be said that the displacement meter is in more extensive use, as this is the type placed on ordinary residential services in which the rates of flow may vary over a rather wide range from practically zero to meter capacity. The most pronounced asset of the displacement meter is its well-known ability to measure very low rates of flow, which, as will be seen later, is certainly of considerable importance.

The current meter, on the other hand, cannot be featured as "sensitive" to low rates of flow, but is rather characterized as a rugged, substantial meter well able to measure accurately over long periods of time the higher flow rates encountered in numerous types of heavy-duty services.

When a service is so variable in its range of demand that it is desirable to utilize the sensitive displacement meter for measuring the low rates and the rugged current meter for the higher rates beyond the range of the former, the two types can be combined into a single unit designed to do that job efficiently. This results in the ordinary compound meter, with a valve arrangement that automatically directs the flow of water into the type of meter best able to handle the particular rate.

Fire line meters are really compound meters which have a comparatively low head loss and an unrestricted full flow—certainly desirable attributes so far as the fire department and the underwriters are concerned. These features are obtained by directing only a portion of the

higher rates of flow through the actual measuring device (either a current or displacement meter), which multiplies mechanically this small diverted flow to record, in effect, the total flow through the entire meter. Fire line meters are also capable of measuring accurately the small flows frequently encountered in such lines, thus satisfying the requirements of the water department as well. Because fire line meters were designed primarily for fire service and not for general service lines, their use on the latter should be considered only when extremely low head loss is a factor of the utmost importance.

TABLE 1

Displacement Meter Registration

Meter Size *in.*	Annual Registration	
	Average *mil.gal.*	Maximum (Any Meter) *mil.gal.*
¾	0.533	2.335
1	1.465	3.860
1½	1.930	4.920
2	3.670	7.875

Selection of Meter Size

The subject of selecting meter sizes might easily develop into a discussion which could cover many pages. The nature of this problem does not permit of easy solution, as there are numerous intangibles introduced by local conditions, one's definition of adequate flow, proper residual pressures at various fixtures, sizes and types of service pipes, distribution of head loss from the street main to the point of highest elevation, peak rates of flow to multiple dwellings and other similar factors. A size which may be considered suitable in one location may not be adequate in another. Fortunately, for most average water plant needs, the ¾-in. meter is appropriate, but there are frequently enough buildings or dwellings requiring large meters to present a problem for the person charged with selecting the size.

If the peak rate of flow to be expected in any building or structure is known, the problem of designing an adequate service pipe and selecting a reasonably suitable size of meter is not very difficult. Too often, however, choosing the proper size of meter as well as of service pipe requires determining the average and peak rates of demand which must be adequately

TABLE 2

Suggested Annual Delivery Range

Meter Size *in.*	Range *mil.gal.*
⅝	up to 0.25
¾	0.25–0.75
1	0.75–1.5
1½	1.5–3
2	3–6

met. There is a scarcity of information, for example, on the rate-of-flow distribution for multiple dwellings or apartment houses. Some work has been done on the analysis of rate-of-flow distribution for premises requiring ⅝-in. meters, mainly to ascertain the usage of water at low rates of flow but also to determine peak demand rates. Studies of this type are very valuable, not only for the selection of meter sizes but also for the proper testing and maintenance of meters.

It may be of interest to quote the results of a study made in one large city on the actual average annual deliveries of various sizes of displacement meters. The area covered con-

sists substantially of large apartment houses, and a reasonable attempt has been made to avoid oversize meters wherever possible. An analysis of the actual installations (practically all apartment houses and dwellings) is given in Table 1 for 120 meters in each size classification.

The 1-in. meters at this plant appear to be getting rather heavy service. The maximum annual registration shown for any particular meter is not typical and the meter may be considered too small for such heavy duty. After a further detailed study of registrations, the engineer of this water company suggested, as criteria for the study of existing records to determine over- or undersize displacement meters, the delivery ranges shown in Table 2 when *annual registration alone* may be the controlling factor. Thus, a 1½-in. meter delivering between 1 and 3 mil.gal. annually would be doing an appropriate job, but if the registration should be, say, 850,000 gal. annually, it might be well to consider using a 1-in. size. This method of analysis of existing records disregards any factor except the ability of the meter to deliver the quantities indicated and to withstand the rigors of such deliveries for a reasonable period.

In general, the use of smaller meters which are able to do the job at hand will be found advisable, as the increased sensitivity or ability to measure the smaller rates of flow may easily result in increased revenue and a higher total of accounted-for water.

Care of Meters

Water meters will give an accurate performance and continue to function well over unusually long periods, provided they are in the best of condition when installed. A ⅝-in. displacement meter, under average conditions, may be left in service for from five to ten years, although frequently it is removed for test and examination after it has measured amounts up to 1 mil.-gal. When it is realized that the passage of this quantity of water in certain makes of meters may cause as many as 50,000,000 nutations of the piston in the measuring chamber, it is quite remarkable to observe the excellent results obtainable with such meters after they are finally removed for test.

TABLE 3

Rate Distribution Study

Flow Rate *gpm.*	Flow Distribution *per cent*
over 15	0.82
12–15	0.39
10–12	0.90
8–10	1.98
7–8	4.90
6–7	6.06
5–6	7.64
4–5	12.95
3–4	11.75
2–3	11.34
1.5–2	9.28
1–1.5	7.93
below 1	24.06
Total	100.00

Since the meter is expected to perform a tremendous task of accurate measurement, some effort to assist it should be made. It is only fair for each meter, before being placed in service, to be given the benefit of every possible advantage that comes from careful inspection and attention. Just as a long-distance runner has to be in excellent physical condition to withstand the grueling pace of a long, hard race, so must the water meter be in fine mechanical condition to meet the vicissitudes of years of service.

It is generally assumed, and rightfully so, that new meters from the factory are in first-class condition and have been correctly calibrated, but quite a number of water departments consider it good practice to test all new meters at their own shop before placing them in service. In certain states, regulatory commissions require that this procedure be followed. In any event, it can be said that the time devoted to the testing of new meters is well spent, as the actual unit cost per meter is very low.

Low-Flow Sensitivity

Since the great majority of meters in service today are of the ⅝-in., or smallest, size, it may be in order to dwell for a moment on the extremely important subject of low-flow sensitivity and accuracy. It would certainly be unwise for a manufacturer to expend considerable time and effort on attaining refinements, and for a meter repairman to devote his valuable time and the use of new parts to repairing meters, if low flows did not occur under actual service conditions. The tendency today is toward the production of more sensitive meters, both on the part of the manufacturer and the repair mechanic, for the very obvious reason that investigations by competent observers have produced ample evidence of a fairly substantial proportion of low-flow usage through the average ⅝-in. meter. It is now realized more fully that for a water meter to earn its way, it must be in condition to measure such small rates of flow. Table 3, taken from one investigator's report in a rate distribution study, shows the results of carefully made experiments conducted with specially selected sensitive meters. These were installed, in the course of the study, in 160 one- and two-family houses served by four different water plants. A total of 7.93 out of each 100 gal. would go through the average meter considered in this study at rates of flow between 1 and 1.5 gpm., or at an average rate of 1.25 gpm. Similarly, at, say, an average rate of 9.0 gpm., a total of 1.98 gal. would flow through the meter.

It may be noted with considerable interest that approximately one-quarter of the total flow was recorded at and below the rate of 1.0 gpm., or within the so-called low-flow region. It is evident that a substantial quantity of revenue water may pass undetected through a meter which fails to record at 0.25 gpm. Is it any wonder that efficient water works repairmen are endeavoring to improve the percentage of registration of their meters at these low rates of flow?

Another point to be noted in Table 3 is the preponderance of water consumed at rates of flow below 12.0 gpm. and the rather insignificant quantity consumed above this rate, which seems to bear out the contention frequently made that a maximum flow rate of 12.0 gpm. is entirely adequate for testing ⅝-in. meters.

Meter Testing

The author is in accord with the sentiment expressed by numerous water works men who claim that the volumetric method of testing is superior to and easier than the weight method. There appears to be little doubt of the simplicity of the volumetric method, and, when one considers the potential error that may be encountered through the use of mechanical scales (many of which are infrequently tested), especially in weighing small quantities of water, it

must be admitted that the volumetric method seems to be productive of greater accuracy.

Although it is true that in volumetric testing at least two tanks are required to do a good job, the overall investment in equipment is considerably less than that for the expensive scales. The use of a small tank for low rates of flow is productive of excellent results, as the elevation of the water in the tank—which actually determines precision of measurement—can be such as to obtain extremely satisfactory and accurate calibrations. It is also said to be much easier to explain the intricacies of a meter test to an irate customer when the volumetric method is used.

In general, the maintenance of meters up to and including the 2-in. size should be performed in the shop, but there is considerable merit in the system of testing and maintaining larger meters in the field under actual service conditions. This latter procedure is especially economical and fruitful of results when the larger meters are of the current and compound types.

The test of a meter—except, perhaps, when new—without a simultaneous inspection of the internal parts tells only half the story. Meters which have been removed from service should be tested for the valuable information so provided, and then, regardless of test results, they should be disassembled and all internal parts examined for wear or defects. After the replacement of any unsatisfactory parts, the meter should be completely reassembled and calibrated at the test bench. Since the meter is expected to do a good job over a long period, it must be made certain that its working parts are in proper condition.

As a rule, expert maintenance men develop their qualifications by traveling the hard road of experience. Manufacturers may point out a few tricks of the trade and some of the fine points of the meter art but a mechanically inclined person who really likes his work and is interested in meter performance should have no difficulty in becoming an excellent meter repairman. Such a person should be taught the limitations of each meter and its characteristics. He should know, for example, from test bench experience with new meters, what test results to expect of an efficient meter, and it must be his aim to put the repaired meter in condition to perform as it should. This combination of a thorough knowledge of meter characteristics, mechanical ability and an honest interest in the work will produce gratifying dividends.

It is the duty of water works operators to be certain that their men are trained properly and that they are kept interested in their job. They should be provided with a modern, up-to-date meter shop, well lighted and well kept, in order that only the most efficient work may be accomplished. An operator who fulfills these obligations will find that many of his problems with meter work will be solved.

Emergencies in City Water Service

By Whitworth Cotten

A paper presented on Oct. 26, 1948, at the Virginia Section Meeting, Richmond, Va., by Whitworth Cotten, City Engr., Petersburg, Va.

THE most frequent topic of conversation, the weather, is responsible for the majority of emergencies that torment the water works operator. Protracted drought drains the normally adequate reservoir, while floods wash out reservoirs, inundate plants and pumping stations, rip loose feeder mains, disrupt electrical services and in general play havoc with water systems. Wind storms and lightning also interfere with electrical service, and even sudden changes in temperature can be blamed for many of the breaks in mains. There are, of course, emergencies due to fires, accidents and failure of equipment or personnel, but the weather certainly stands out as Public Water Works Enemy Number One. The purpose of this paper is to present some practical observations on how to prevent certain failures and a few suggestions on dealing with those that do occur.

Duplicate Units

The best way to avoid a serious emergency is to have a system which is not dependent upon any one unit, but this is economically impractical except in very large cities with numerous sources of supply, filtration works and pumping stations. Each water system must be studied to find the weak points which require duplication, and there is no general rule to apply.

Two independent sources of supply provide a factor of safety which is reassuring. Where this arrangement is not feasible, duplicate mains along different routes from the source to the plant or distribution system are desirable.

There is no substitute for adequate elevated storage to carry a water system through the average emergency, especially when provided in duplicate. It is frequently too expensive to rely only on elevated tanks for this storage, and, when the topography offers no assistance, it is difficult to store as much as 50 per cent of the maximum daily demand. The duplication of service pumps then becomes necessary, particularly if priming pumps are required for operation.

Chlorination should never depend on a single installation, and each unit of a duplicate installation should be adequate to supply the maximum load. It is desirable to have at least one spare chemical feeder suitable for any chemical used.

The use of two mains, preferably along different routes, to connect the pumping station or major reservoir to the distribution grid provides a comforting safeguard for the conscientious operator. The distribution system in most cities generally has sufficient valves and alternate mains to isolate a break and shut off only the immediate

area. Breaks can be very troublesome but seldom create a serious emergency unless several occur at one time, as has happened in floods.

Standby Service

Electricity is now the major source of power for pumping in water works. The reliability of this source has so improved in the last decade that the importance of adequate standby service is frequently overlooked. Numerous recent articles in the JOURNAL have cited many examples of disruption in electrical service from a few hours to several days. Except where elevated storage is adequate, standby units should be able to supply at least 60–70 per cent of the maximum daily demand.

The sources of power for standby units are steam, diesel or gasoline engines. Steam is used chiefly in plants where it has been abandoned for ordinary service. Gasoline engines are usually preferred to diesels when employed exclusively as standby units, because the initial cost is much less and the higher operating cost is not a factor in standby service.

Practice is divided as to the method of applying standby power to the pumps. Some installations use generators to drive the service pumps and others furnish the standby power directly to them. The former method gives a neater design and more flexible operation, eliminating the need for a small generating set for lights and incidental power for chemical feed and pump-priming motors. Direct power has the advantage of providing service during failures of electrical equipment in the plant.

Every city has an excellent source of emergency standby equipment in a fire pumper. Petersburg, Va., has a very cooperative fire chief and the water department has called on him four or five times in the last eight years for assistance. On one occasion an area of 5,000 population was supplied by one pumper for four hours. In another emergency 12,000 persons were supplied by the use of two pumpers for five hours. The pumpers took suction from the 4½-in. connection on a low-service hydrant and discharged into two 2½-in. hoses connected to outlets on a high-service hydrant.

Good use is being made of three O.C.D. skid fire pumps purchased very cheaply by the city. Two have been installed in the main pumping station for standby on the high service. These pumps take suction from the clear well and, operating together, deliver approximately 800 gpm. at 140 psi. The third pump is to be used in an outlying pumping station. This is an economical installation for a small area.

The importance of routine testing of standby equipment cannot be overstressed. Too often the units are found to be inoperative when an emergency arises. This equipment should be put into actual service for an hour at least once a month. A program of preventive maintenance should be followed, similar to that practiced by owners of large automotive fleets.

Safety Measures

Contamination of the water supply, always a danger when any serious emergency occurs, may come from broken mains, flooded reservoirs or interconnections and faulty plumbing as a result of reduced pressures. It is essential that intelligent use be made of available chlorine equipment to provide adequate residuals throughout the sys-

tem. For field use it is desirable to have portable chlorine apparatus, but, if this is not available, effective results may be obtained by the injection of chlorine gas from cylinders directly into the main. The easiest method of treating broken mains is to insert hypochlorite in the ends prior to closure. The operator in his rush to restore service must never lose sight of his responsibility to deliver a safe water, even in emergencies.

Chlorinating equipment should never be located in places containing other apparatus and should be installed in rooms with all openings leading to the outside of the building. If interior doors are necessary, these should be self-closing fire doors. Approved gas masks should be provided for the operating personnel.

Electrical Connections

When practical, duplicate circuits should be installed from the electric substation to the major pumping stations. Alternate services are advantageous, particularly if the service is underground. The value of duplicate service was forcibly demonstrated in two recent failures at the Petersburg plant. Half of the pumps at the main station are powered by 4,000-v. motors and the rest are served by 220's. The 4,000-v. underground service failed and operation was resumed within minutes by transferring to units powered by the 220-v. motors. Six months later an identical failure occurred at an outlying station, but this time service was disrupted for approximately 24 hours, because of the lack of an alternate service. Fortunately an auxiliary supply of water was available.

Conclusion

Although the elements are usually responsible for the majority of water works failures, many can be avoided by thorough preparation for emergencies. Greater consumption and demands for extensions, together with the high construction cost and the shortage of materials, have increased the difficulty of improving or maintaining water plant safeguards, but every practicable method of raising the safety factor should be applied.

Replenishment of Ground Water Supplies

By E. W. Bennison

A paper presented on Sept. 26, 1947, at the Rocky Mountain Section Meeting, Denver, Colo., by E. W. Bennison, Civ. Engr., Office Engr., Edward E. Johnson, Inc., St. Paul, Minn.

GROUND water replenishment, unlike conservation, depends on conditions which are not and cannot be controlled by legislation. It is apparent that the amount of water which can safely be taken from any ground water development must not exceed the quantity which will be restored to the zone either naturally or artificially. It is not easy to determine the amount of recharge, though it is well known that the principal source of ground water is downward seepage from the surface, either directly from rainfall or melted snow or from rivers and lakes supplied by rain or snow. How much of it finally becomes a part of ground water storage is the question. First, there is the infiltration into the soil or other material lying directly below the surface, then the downward seepage through the dry zone above the water table and finally the delivery of part of the water to the zone of saturation, where it becomes ground water.

Natural Recharge

The amount of water that is added to ground water storage from influent and effluent streams must be considered in any calculations of recharge. In some parts of the country, surface streams may be influent without exception. In other areas, they may be both influent and effluent or principally effluent. In the western United States, most of the rain and snow falls on the mountains, while the valleys in between may be dry. The streams rise in the mountains and are fed by springs and melted snow. When they leave the mountain canyons, they flow over alluvial slopes, largely of their own construction. Such streams are the principal sources of ground water recharge in the West. In the central and northwestern part of the United States, the supply of ground water is chiefly from local rainfall. Just how much goes to recharge depends on the time of year and the amount of precipitation. During the growing season, unless the rainfall is very heavy, there will be little or no recharge.

Recharge or ground water replenishment, therefore, depends on the annual precipitation and the intake capacity of the surfaces upon which it falls. Because precipitation varies in quantity from place to place, there is no fixed ratio of recharge to precipitation. In the same way, the intake capacity of the surface formation varies from that of sand and gravel to that of solid rock. Furthermore, the nature of the underlying strata also determines the intake capacity of the surface formations. The shape of the land surface is another element which influences the surface intake capacity and consequently the amount of ground water recharge. These are factors the average person does not think of when undertaking a ground water development.

Artificial Recharge

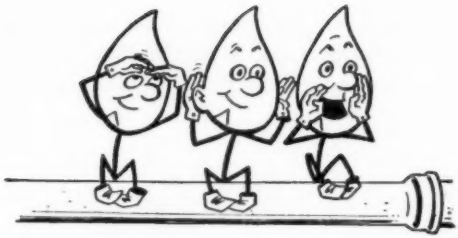
Recently the conservation of ground water has become so essential that natural replenishment has been supplemented by artificial recharge. In returning water to underground formations, there are two methods that have been used with more or less success. One is water spreading; the other, recharge wells. The practicability of both of these methods has been demonstrated in many places in this country and Europe. Water spreading is much older and there are many arguments in its favor, but it is dependent on the availability of large quantities of water on the surface above the area to be recharged.

By using this method, water may be stored underground during wet years and used in dry years. Not long ago the U.S. Geological Survey made an investigation to determine the amount and effect of recharge from the Ohio River to the water-bearing deposits in the river valley. Although this was not water spreading, the sources of supply were local rainfall and infiltration from the river. The data obtained indicated that the amount of recharge from the river depended on the difference in elevation between ground water and river water levels, the area through which the river water was passing and the location of wells with reference to the river.

In spreading operations in California, Lane found the rate of downward percolation to be approximately 20 ft. a day and the mean velocity of horizontal percolation to be about 3.68 in. a year. In Des Moines, Iowa, recharge by flooding has been practiced for some time as a means of supporting the ground water level in the permeable formations along the Raccoon River.

Recharge wells are relatively new in the field of well construction. What were called drainage or inverted wells have existed for many years, but the necessity for recharging underground storage reservoirs and legislation requiring the return of ground water used for certain purposes have led to the recharge well. In general, this type follows the lines of a discharge well, the object, of course, being to return water to the ground rather than to obtain it from the ground. Recharge wells are most successful in creviced rock formations, though many have been built on Long Island which return water from sand-gravel formations to the dry sand-gravel formations above the water table. Thus, a recharge well may properly be called a diffusion well, depending on the purpose it serves.

There are many elements to be considered before attempting to return water to the ground by means of a well or by flooding. Most engineers agree that such projects are feasible if a sufficient distance or depth is available from the ground surface to the normal water table and the formations below the surface are sufficiently pervious for water to pass readily and freely to the water table without becoming perched or diverted by impervious formations that would lead the percolating water away from the ground water storage reservoir. The permeability of the formations above the water table affects the rate of diffusion. It is apparent, therefore, that in many areas the ground conditions and economic limitations would make artificial recharging by either wells or flooding impractical. In other localities, where ground water has a higher value and conditions for recharging are favorable, artificial recharging will become an established practice.



Percolation and Runoff

The evaporation of the dry ice myth and its attendant wistful weather wonders (*see* January P&R p. 4) has been accompanied by a rapid resurgence in the temporarily despondent art of weather forecasting. Thus have we learned in the past few weeks: that Army weather probers are source-seeking with V-2 rockets, firing their instrument-equipped missiles some 100,000 to 200,000 ft. into the stratosphere to measure ethereal wind velocities; that Weather Bureau stations are being equipped with the newest radar devices for storm detection; that private forecasters are experiencing a business boom in keeping industrial, and even municipal, customers informed of the specific climatological facts of business life; and that sometime snowstruck New York City started the new year with a new weatherman.

All this revitalization is understandable enough, of course. Granting the scientific accuracy of the conclusion that we can't do anything about weather, it must logically follow that knowing about it in advance is an advantage in that it will permit us to mitigate its effects. But having spent our Christmas day all woolied up and with our shovel poised to combat the predicted, but unappearing, "worst snowstorm in New York's history," we begin to wonder if the fright isn't worse than the bite. After all, it requires no superscientific background to observe that Nature is a fickle dame. And if we can't bend her to our will, what makes us think that we can outguess her? To our way of thinking, there are better ways to prevent, for instance, flood damage than by predicting that specific rain clouds will probably loose their contents over a specific floodable area. And if the occasional accuracies of weather forecasters are at a longer range than our Uncle Abner's rheumatic leg, their relative infrequency still leaves them suspect enough to counteract at least some part of their value.

If this sounds like "sour grapes" at the loss of so valued a toy as was rainmaking, we're not too surprised, for it was a bitter blow. But we must recall, too, the number of times we carried our umbrella, cancelled our picnic and didn't go to the ball game on the sunniest days of the year. As

(*Continued on page 2*)

(Continued from page 1)

yet we're only disillusioned, and in the news of progress there may yet be hope of our escaping outright cynicism, but never while our weathermen subscribe to these sentiments posted on the New York Weather Bureau wall:

As we appoach life's gray December,
These in the main are our regrets:
When we're right no one remembers.
When we're wrong, no one forgets.

In our disillusionment, we can respond:

We rue your plight, we're sympathetic,
If our unkindness is unjust;
But we'll not be apologetic
Until your forecasts we can trust.

Were we cynical, of course, our own verse would be blanker—or even blankety-blanker—and we would harbor no solicitude for the martyrical meteorologists. It'll be a cold day in . . . Well! It'll be a cold day when we wear our rubbers again because a weather report predicts rain.

A recommendation to end city control of Philadelphia's water system was made by consulting engineer Charles Haydock, who had been commissioned to make a survey of its operations by the civic-minded "Committee of Fifteen." Charging that maintenance was in arrears, that revenues were lost to the general city treasury, that personnel were inadequate and over-age, and that the metering program was inadequate, the report called for transfer of the water utility to private enterprise under a leasing arrangement, or to a separate authority. "Many of the recommendations could also be carried out under the present operation," the report charged, "but experience indicates that this is not likely." The only immediate result of the report was for the City Council, at the recommendation of the "Fifteen," to increase water rates by 20 per cent.

A "Bibliography on Water and Sewage Analysis" has just appeared as special report No. 28 of the Georgia Engineering Experiment Station. Compiled by B. H. Weil, Poagie E. Murray, George W. Reid and Robert S. Ingols under a grant-in-aid from the National Institute of Health of the U.S.P.H.S., the bibliography contains 2,560 entries devoted to chemical analysis, classified under 36 major and several score minor headings, as determined by the constituents to be analyzed. A separate cross-reference list is set up according to the procedure called for, such as centrifuging, colorimetric, microscopic, and so on. The 215-page, cloth-covered bibliography is priced at $4, and copies may be obtained from the Director, State Engineering Experiment Station, Georgia Inst. of Technology, Atlanta, Ga.

(Continued on page 4)

At Coachella Valley

Lower Cost of Delivered Pipe Means Savings in Cost of Delivered Water

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(*Continued from page 2*)

Many employers in the water, light, power and heat industries are violating the Fair Labor Standards Act and the Public Contracts Act because they do not understand how these basic wage and hour laws affect their employees, according to W. R. McComb, U.S. Department of Labor administrator. Inspection of 313 utilities during the year ending June 30, 1948, revealed that $418,568 in back wages were due to 3,283 employees because of violations. The most frequent cause of violation was failure to pay time-and-a-half rates for more than 40 hours of work a week; failure to pay the minimum rate of 40¢ an hour was also cited, although it occurred less often. The Fair Labor Standards Act affects employees engaged in interstate commerce or in the production of goods therefor, and included occupations necessary to such production. The Public Contracts Act applies to employees engaged in government manufacture or supply contracts in excess of $10,000. McComb urges employers who are uncertain about the provisions of the laws to consult the Wage and Hour and Public Contracts Divisions of the Labor department.

The calamity howling of the public press may suffer a setback one of these days if a success is made of the *Good News Bulletin,* a new publication founded by a newspaper correspondent who was fed up with the "daily dose of catastrophes, crises and cynicism" dirged out by the newspapers. Claiming that it is not necessary to make like an ostrich to see a brighter side to the news, founder Robert B. Jung is intent on proving that journalism need not be all "dissension, fear and hate" to hold reader interest. And where we fit into the picture is in providing one of the most prominent headlines of the first issue: "Better Drinking Water for Pennsylvania."

Actually, Mr. Jung's idea is no more quixotic than the thesis which we have been trying to put across in our public relations campaign for some time now. The water supply, we contend, is news; and if it is practically all good news, that doesn't lessen its value as good copy. Thus we shall watch with more than passing interest the impression which Mr. Jung makes, not so much upon the press as upon the public, whose alleged avid interest in "murder, rape and arson" is said to be the first cause of grisly glamor that pervades the hysterical history of our times.

Not to disprove our previous point, we can still point out that there is some good news in our calamitous chronicles, and good news of water, too, if we have the patience to look for it. In the past month's papers, for instance, we were happy to note:

That Los Angeles *Times* columnist Henry McLemore, on his return from a world tour, saw fit to pay tribute to American water works for providing the only uniformly safe tap water supplies in the world. And if

(*Continued on page 6*)

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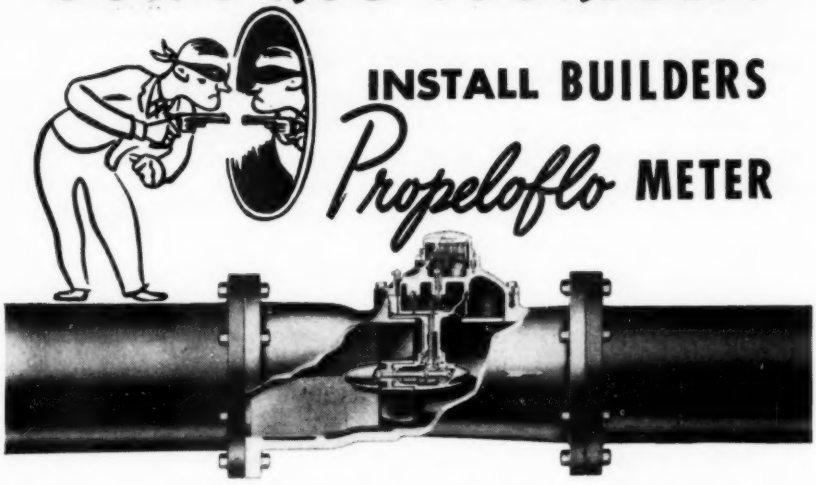

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BUILDERS PROVIDENCE
Instruments

(*Continued from page 4*)

his encomium was a bit overexuberant, we can still appreciate his appreciation of the fact that pure water is more an accomplishment than a happenstance.

That both newspapers and radio made capital of the fact that high priority on the Christmas list of Americans living in Esso Standard Oil Co.'s colony on Aruba island, off Venezuela, was given to "pure drinking water," 2,600 gal. of which were ultimately drawn from the North Jersey District Water Supply Commission system at Bayonne and dispatched by tanker rather than by sled.

That the proposed constitution of the new state of Israel includes an article providing that the state enact legislation to ensure proper conservation and utilization of water for the benefit of the people.

That growing Puerto Rico was proud enough of its water supplies to make its progress in that field a key factor in advertising the island's economic advantages to prospective business men.

And, finally, that every year-end review of the nation's health status recognized the contribution of public water supplies to the people's better health.

(*Continued on page 8*)

GLOSSARY—

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Scheduled to appear in March or April, the Glossary has been offered to A.W.W.A. Members at a special price of $1.00 per copy for the paper-bound edition, or $2.00 per copy for the cloth-bound edition, in a special membership mailing dated January 31, 1949.

The needs of nonmembers will be taken care of at a later date at advanced prices, but if you're a member, be sure to reserve your copies now at the special membership price, from:

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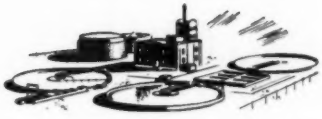

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(*Continued from page 6*)

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Edward J. Cleary, formerly Executive Editor of Engineering News-Record, has accepted the post of Executive Director and Chief Engineer of the Ohio River Valley Water Sanitation Commission. The compact establishing the commission, which will attempt to clean up the waters in the Ohio valley, went into effect on June 30, 1948. An area of nearly 155,000 square miles in eight states, and inhabited by nearly 16,000,000 people, is involved. Headquarters is at 410 First National Bank Bldg., Cincinnati, Ohio.

William E. Vest, Water Department Consultant for Charlotte, N.C., died on December 30, 1948. A Member since 1911, he had been a Director of the Association in 1930–31 and in 1942 was elected an Honorary Member.

•

Wayne W. Wyckoff, Aqueduct Engineer for the Los Angeles Department of Water & Power, died as the result of an automobile accident on October 27, 1948. He was on his way to attend the California Section meeting at Riverside when the crash occurred.

At the age of 46, Wyckoff was one of the department's youngest and most popular executives. He had joined it as a junior civil engineer on the Colorado River survey project shortly after his graduation in 1925 from the University of California. Later he worked in the Water Design and Field Engineering Divisions, became resident engineer on the Mono Basin project, and in 1945 assumed the post he held until his death.

Ray F. Goudey died on December 16, 1948, less than seven weeks after opening his own office and sanitary engineering laboratory in Los Angeles. He was 55 years old. He had served with the California department of public health from 1917 until 1929, when he joined the Los Angeles Department of Water and Power. Among his many A.W.W.A. activities had been membership in various committees, the posts of Director for the California Section and of Chairman, Founder Member, and Purification Division Organizing Secretary for that Section. He had also been honored with the Goodell Prize and the Fuller Award.

(*Continued on page 10*)

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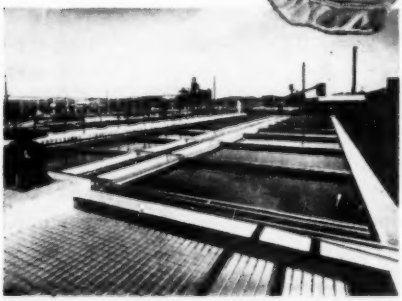

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- Adaptability to Variable Rates of Flow
- Low Turbidity
- Lengthened Filter Runs

FOR 35 YEARS
WATER CONDITIONING HEADQUARTERS

Permutit

(*Continued from page 8*)

Just what the doctor orders, in at least two too common diseases, is what water works men provide without prescription. Not long ago two heart specialists, speaking at the University of Kansas Medical Center, reported a definite drop in dropsy deaths due directly to water therapy. Two to three quarts a day, straight, and straight from the tap, plus the amount available in four to six glasses of milk per day, they determined to be the proper dose. And then, of course, what's almost common knowledge now, is the principle of drowning a cold.

Less well established, but certainly not to the discredit of water, are the curative claims, supported by various arthritics, rheumatics, asthmatics, kidneyics and other sundry sufferers, for waters either general or specific. Yet one disease which is almost always unexplainably omitted from water's therapeutians is dipsomania. Can it be that modern man has forgotten that "on the wagon" originally read "on the water wagon"?

Well! Well! The first of which was dug in Budapest, Hungary, by oil seekers, who found it yielded only water; the second of which was dug in Fond du Lac, Wis., by water seekers, who found it yielded only gasoline. And thereby hang two tales:

Now, ten years after it was abandoned, the Hungarian well is back in favor as a producer which may yield valuable minerals. Analyzed, the water therein available was found to contain 2.3 per cent sodium bicarbonate, 0.5 per cent sodium chloride and a significant percentage of iodine.

And now, ten years after it was drilled, city officials are afraid that the Fond du Lac gasoline producer is running dry. Having yielded an estimated 20,000 gallons of refined, low-octane fuel good enough to mix with commercial gasoline for use in city trucks, the well has never yet been explained by petroleum experts or anyone else for that matter.

All of which is enough in the style of Aesop to allow you your own moral. But this is a fable founded in fact, to which only the parallel phraseology has been added.

(*Continued on page 12*)

MAKES WATER BRIGHT

AND BETTER TASTING TOO!

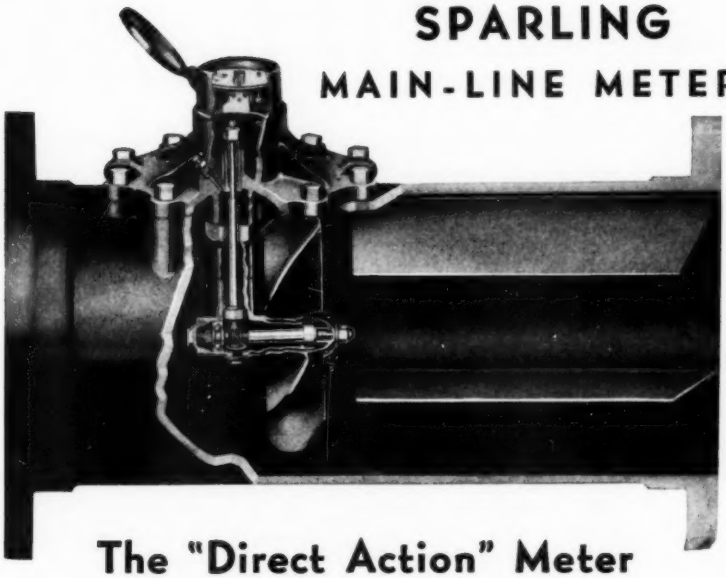
STUART
CORPORATION
BALTIMORE

CONTRACTORS OF PUBLIC WORK
SPECIALIZING IN
PALMER SURFACE WASH SYSTEMS
AND
KWIK-WAY FLOCCULATION SYSTEMS

ESTIMATES NO OBLIGATION

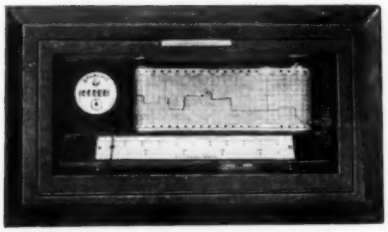
STUART CORPORATION · 516 N. CHARLES ST., · BALTIMORE 1, MD.

SPARLING
MAIN-LINE METERS



The "Direct Action" Meter

THE Sparling Main-Line Meter totalizes directly at the meterhead—no further instrumentation necessary! The meter is as easily installed as a length of the pipe itself. For Service and Satisfaction over long years, with Low Head Loss, choose the Sparling!



INDICATORS – RECORDERS – CONTROLS

For reading and recording flow-rates, a wide variety of equally accurate instruments is available. Also Controls for auto-metered chemical feeds.

Quotations gladly given. Bulletin 310 comes upon request.

R. W. SPARLING
Manufacturer of WATER MEASURING EQUIPMENT

LOS ANGELES 54 . . Box 3277 Terminal Annex
CHICAGO 8 . . . . . 1500 South Western Ave.
BOSTON 8 . . . . . 6 Beacon Street
622 Broadway . . . . . CINCINNATI 2
101 Park Avenue . . . . . NEW YORK 17
1932 First Avenue . . . . . SEATTLE 1

(*Continued from page 10*)

Alfred E. Williamson Jr., consulting engineer of the firm of Russell & Axon, Daytona Beach, Fla., has been made an honorary professor of sanitary engineering in the School of Exact Science of the Univ. of San Andres, Bolivia. The honor was conferred in recognition of his work in that country as chief engineer and later chief of the U.S. sanitary mission in 1944–45. Among other projects for which he was responsible was the founding, equipping and staffing of a department of sanitary engineering in the school.

Our cow-mood analysis of last month (*see* January P&R p. 8) was quite definitely at variance with the *Saturday Evening Post's* interpretation of a similar instance described in its Christmas issue. From Kentucky rather than Texas, and fattening his cattle for meat rather than milking them, the *Post's* cow-keeper, like ours, experienced a real advantage to his herd by using a highly mineralized well or spring water instead of rainwater or the city's purified supply. In reporting farmer Weil's inquiries into the matter, author Neil M. Clark cites his question as to whether water purification was taking "too much" out of water, going on to question the propriety of our "closed book" attitude on drinking water and pointing out that many nutritionists think water has a positive nutritional role and that many physicians think "it makes a difference what elements are in it beyond H_2O." Concluding his piece, Clark suggests that: "doctors, biochemists, nutritionists, water purification experts—all need exact knowledge about the desirable composition and balance of forces, and the essential bodily functions of water."

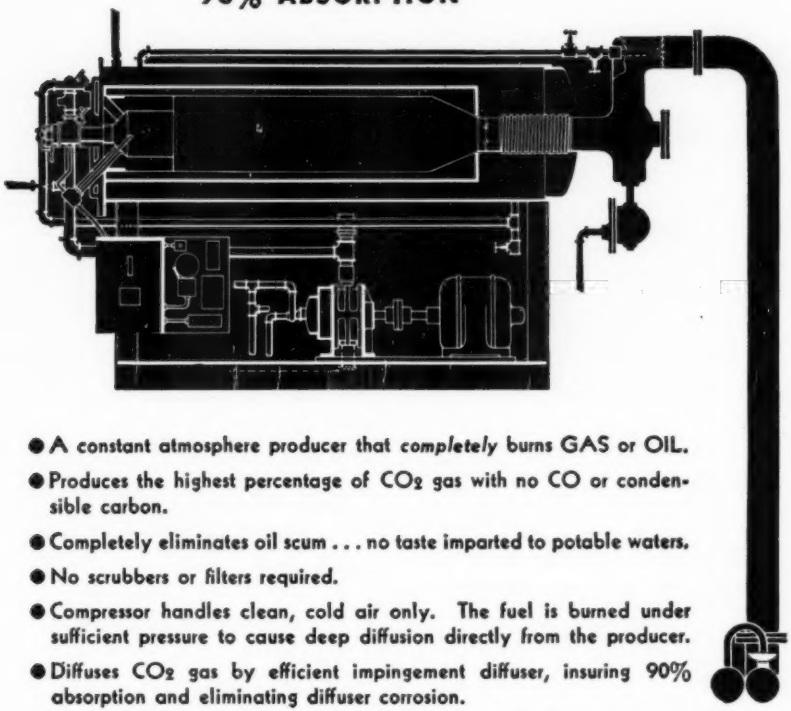
Now, if our consumers, bovine or otherwise, indulged in no other form of ingestion than the imbibition of water, we might consider concocting a Clarkian tonic, but let us content ourselves with pointing out that the "book" must have looked closed only because of the angle from which he was examining it.

(*Continued on page 14*)

CO_{TWO} UNIT...

SPECIFICALLY DESIGNED FOR THE CLEAN, EFFICIENT RECARBONIZATION OF LIQUIDS

90% ABSORPTION



- A constant atmosphere producer that *completely* burns GAS or OIL.
- Produces the highest percentage of CO_2 gas with no CO or condensible carbon.
- Completely eliminates oil scum . . . no taste imparted to potable waters.
- No scrubbers or filters required.
- Compressor handles clean, cold air only. The fuel is burned under sufficient pressure to cause deep diffusion directly from the producer.
- Diffuses CO_2 gas by efficient impingement diffuser, insuring 90% absorption and eliminating diffuser corrosion.
- A factory-tested, package unit with air compressor, fuel pumps, burner, control panel and all safety devices and appurtenances mounted on one frame.
- 50% more chemical efficiency than any other method in current practice.

WRITE FOR BULLETIN 757

WALKER PROCESS EQUIPMENT INC.

EQUIPMENT • EQUIPMENT ENGINEERING

PROQUIP AURORA • ILLINOIS

(*Continued from page 12*)

Harald M. Olson, formerly manager of the Ohio Salt Co.'s water softening division, has been appointed Consulting Maintenance Engr. for the Morton Salt Co.

An examination for the post of Public Health Engineer in the Seattle, Wash., Dept. of Public Health will be held shortly. The salary is $550 monthly and the usual residence requirement has been waived. Applications must be filed by February 28th. Forms are available from the Seattle Civil Service Commission, 325 County-City Bldg., Seattle, Wash.

An ingenious "frost-proof" hydrant, which eliminates the need for underground drainage by actually permitting the water to stand and freeze in the portion of the riser spout above the frost line, has been designed by Crane Co. of Chicago. A narrow rubber tube, installed under tension, leads from the valve to the opening above ground. With the water pressure turned on, the tube expands against the inside of the riser, permitting free flow. When the valve is closed, the tube contracts, and only a thin pencil of ice can form, which is easily broken up and flushed out when the valve is again opened.

(*Continued on page 16*)

For Sale

Immediate Delivery

CAST-IRON PIPE AND FITTINGS

150 psi. Pressure — B. & S. A.W.W.A.

New Pipe—4, 6, 8, 10 and 12 in.
Reconditioned Pipe—12, 16, 20 and 24 in.
Valves—All Sizes—New and Reconditioned
Flanged Pipe—6, 8 and 10 in. New
—12 and 14 in. Reconditioned
C-I. Water Pipe Fittings—All Sizes and Kinds
Soil Pipe—From 2 to 15 in., and Fittings. Immediate Delivery

Tagco, Inc.
111 Front Street
Hempstead, L.I., N.Y.
Telephones: Hempstead 2-5535 and 8857

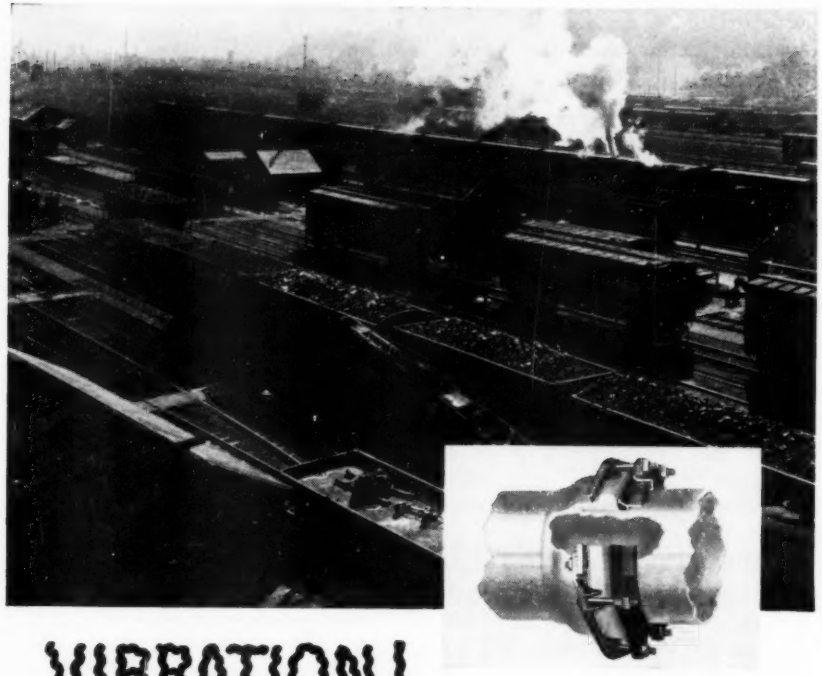
For Sale

C.I. FLANGE PIPE AND FITTINGS

Immediate Delivery---
A.W.W.A. Standard

3—30 in. 90° Bends
1—30 in. 90° Bend, Long Radius
1—20 x 20 x 20-in. 90° Bend, Side Outlet
4—20 x 20 x 20-in. Tees
3—16 x 16 x 16-in. Tees
2—20-in. 45° Bends
4, 6, 8, 10, 12, 14, 16, 20, 24-in. Pipe

Tagco, Inc.
111 Front Street
Hempstead, L.I., N.Y.
Telephones: Hempstead 2-5535 and 8857



VIBRATION!

But water lines stay bottle-tight

Here, in the Russell, Kentucky, yards of the Chesapeake and Ohio Railway, water lines are undisturbed by terrific pounding because they are protected by Dresser Bell-Joint Clamps.

C & O's Chief Engineer writes:

"The use of Dresser Style 60 Bell-Joint Clamps has been standard on our railroad for the past fifteen years. They can be found in any of our yards."

Or take the case of Buffalo, where the water department used to keep two repair gangs busy every day of the week repairing leaks in the railroad yards. Buffalo finally clamped these lines and reported a year later, "not a single leak since we clamped".

These two examples indicate the ability of Dresser Style 60 Clamps to hold joints tight—even under the most difficult operating conditions. Today, when water consumption and operating costs are both at peak levels, you'll find it more practical than ever to use Dresser Clamps for all your repair work on leaking bell-and-spigot joints or as a precautionary measure where excessive vibration can be anticipated.

Completely adjustable, they can be quickly and easily installed without service interruptions even on foreign pipe or otherwise off-size bells and spigots.

Dresser Style 60 Bell-Joint Clamps are available in sizes from 3″ through 60″. Write for free factual information.

DRESSER BELL-JOINT CLAMPS

Dresser Mfg. Division (One of the Dresser Industries), Bradford, Pa. • In Texas: 1121 Rothwell St., Houston • In Canada: 60 Front St., W., Toronto • Sales Offices: New York, Chicago, Houston, San Francisco

(*Continued from page 14*)

That crime shall not pay is a dictate of Hollywood's Johnston office, which, incidentally, every police department in the country follows to the best of its ability. Thus it was no great surprise last December to find that the law had finally caught up with an unauthorized utility bill collector who had managed to take in about $300 per week for some six years from unsuspecting Brooklyn housewives. As a matter of fact it was only a missing fingertip which led to his eventual identification and arrest. And the probability that gas, electric and water commissioners are vying for his services upon release need not be mentioned here. Nor was it any surprise to find police, guards and private detectives swarming all over the New York National City Bank one morning when a water main break flooded the bank vault and set off its complicated system of burglar alarms. But our story from Montclair, N.J., this month must have been conceived as a serial, for no one has yet apprehended the culprit who walked off with a pile of 100 paving blocks at high noon, while the water department workmen who had ripped them up were away for lunch. Or *does* crime pave?

What Price Progress: *When,* according to *Monsanto Magazine,* it now takes a chemist 600 words, by actual stenographic count, to describe a glass of water. *When,* according to Robert Smith-Johannsen of General Electric laboratories, water, in the absence of any foreign nucleating material, freezes at -20°C. instead of at the 0°C. temperature we used to learn. *When,* as reported in the New York *Star,* it requires constant checking of 50 test wells around the Brookhaven atomic energy laboratory to make certain that the ground water isn't being radioactivated. But then, perhaps it would have been smarter of Colorado Springs city officials recently to use a more progressive tool than dynamite in removing the hazard of an overhanging chunk of granite. After all, the cost of the water pumping station the boulder demolished when it was blasted loose and allowed to roll would indicate some price for lack of progress too.

(*Continued on page 18*)

BOND-O

A safe and dependable self-caulking, self-sealing compound for jointing water mains. Used with complete confidence by hundreds of water works.

BOND-O is machine-blended for absolute uniformity and contains a germicide to inhibit oxidation by sulfur bacteria. BOND-O Rubber Packing Gaskets are resilient—bacteria-free and quickest of all packings to install. Made in sizes 4" to 14".

Northrop

NORTHROP & COMPANY, INC.
SPRING VALLEY, N. Y.

• Every Bond-o Joint is a Good Joint •

THEY TELL ME THE PARTS IN THIS WATER METER ARE INTERCHANGEABLE -
YES, AL, THAT'S TRUE. OUR BUFFALO METERS ARE FULLY INTERCHANGEABLE -- PART FOR PART, NOT JUST UNIT ASSEMBLIES !

● The individual parts . . . measuring chamber halves, gears, bearings, and all internal parts in AMERICAN and NIAGARA Water Meters have been *fully interchangeable* for many years . . . cutting maintenance costs to a minimum.

BUFFALO METER COMPANY

2914 MAIN STREET, BUFFALO 14, N. Y.

(Continued from page 16)

Riding the hobby horse these days is none other than our good friend the Superintendent of Documents, who deposited in our mailbox, along with the specifications we recently ordered from the Government Printing Office, a little booklet, entitled "What Is Your Hobby?" Reassured by its readability that this was not another official pestionnaire, we have done nothing more yet than to browse through its pages looking for a satisfactory personal answer. By now, however, we have managed to narrow down the choice to one between "Techniques of Fishpond Management" and "Savory Herbs, Culture and Use," and because we're determined to use our bathtub sometime before summer sets in, it will undoubtedly be Herb who wins out in the end. Not long on culture, either, we'll be sticking pretty close to use, with the conviction that it will be worth the 10¢ price of the book just to find some use for those cardamom seeds someone once left in our cupboard. Incidentally, though, if you are afflicted with a hobby or foolish enough to want to expose yourself to one, the booklet will give you some ideas, listing inexpensive publications on everything from woodworking to cartography, from judo to motion picture projection.

But speaking of hobbies reminds us to record approval here of one indulged by Metropolitan Opera soprano Stella Roman, who has collected water samples, raw [raw water samples, that is], from the rivers and oceans she has met since she began her vocal trouping in Cairo in 1935. The fact that she uses perfume bottles rather than test tubes in which to store her souvenirs shows perhaps more appreciation of their often aromatic qualities than is demonstrated by our laboratorians. Feeling as we do about opera, we wonder if it would be considered just as great a compliment if we were to bottle up a collection of sopranos, especially coloraturas, and give up right now on herbs.

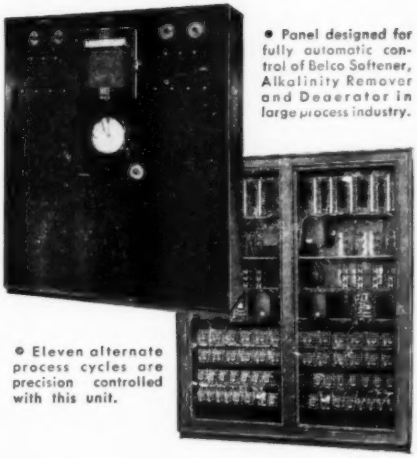
George W. Pracy, A.W.W.A. President in 1932–33 and superintendent of the city distribution division of the San Francisco water department until January 1, has been appointed chief engineer and general manager of the department, succeeding Nelson A. Eckart. Eckart has retired after 36 years of service to the city.

Harry T. Campion has resigned for the second time as superintendent of the Defiance, Ohio, water works. He left the post after seven years in 1926 to join the water department of Grand Rapids, Mich., but returned in 1942.

The position of Superintendent of the Cedar Rapids, Iowa, water works will be filled as the result of a competitive examination to be held soon. Further information is available from Miss Marguerite Kane, Secy., Civil Service Commission, Cedar Rapids, Iowa.

FOR FULLY AUTOMATIC CONTROL OF ALL WATER TREATMENT PROCESSES

EXPERIENCE COUNTS



• Panel designed for fully automatic control of Belco Softener, Alkalinity Remover and Deaerator in large process industry.

• Eleven alternate process cycles are precision controlled with this unit.

Belco engineers are thoroughly experienced in all phases of completely automatic water treatments. By applying this wide experience to your processes you can avoid the losses that result from outdated control — you can reap the savings that result from modern simplified automatic Belco control. Experience counts . . . Belco has, for example, the advantage gained through designing and building the world's largest fully automatic demineralization and silica removal plant.

MODERNIZATION OF EXISTING PLANTS RESULTS IN LARGE OPERATING SAVINGS

Ask a Belco engineer how modernization might effect substantial savings in your present operations. Ask about the application of the Belco automatic controls to other processes in your plant.

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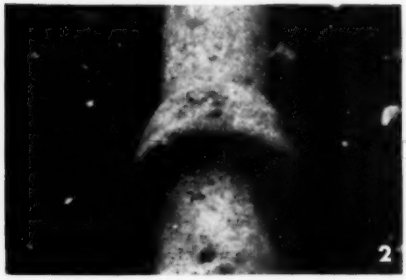
Midwest: Deady Chemical Co., Kansas City, Mo. • Southwest: Watermasters, Inc., Houston, Tex.
Pacific: Deady Chemical Co., Los Angeles, Cal.

Belco

PROCESSES FOR REMOVAL OF WATER IMPURITIES



(1) This 101-year-old cast iron water main is serving Frederick, Maryland.

(2) Still in use after 118 years of service in the water supply system of St. Louis, Mo.

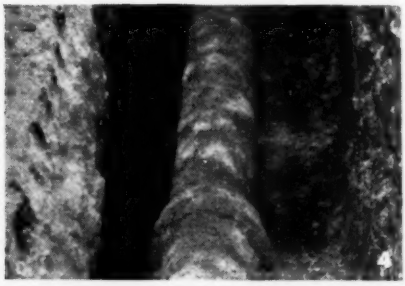
(3) This water main, installed 117 years ago, is still serving Richmond, Va.

(4) Lancaster, Pa. laid this cast iron water main 105 years ago. It is still serving.

(5) One of several cast iron water mains that have been serving New York City for more than a century.

(6) America's oldest cast iron water main, now in its 132nd year of service in Philadelphia.

(7) This cast iron water main has been serving Boston for 120 years.



CAST IRON PIPE

Going strong in their 2nd Century

About 30 of the older American cities have cast iron water or gas mains in service which were laid from 100 to 132 years ago. Most of these mains, on or after their 100th Anniversary, have been uncovered, inspected and photographed for the record. Seven of them—all water mains, are shown in this advertisement.

While it is well known that cast iron water mains in England, France and Germany have service records that approach three centuries, we, who make cast iron pipe, nevertheless get a thrill out of looking down into the trench at an uncovered section of a main that has been in service for 100 years—and so, we are told, do water works and gas engineers.

When one considers the radical changes which have occurred in a century in vehicular traffic, and the vast development of underground construction for the many utility services, the fact that these mains are now in their second century of service is all the more remarkable. Cast Iron Pipe Research Assn., T. F. Wolfe, Engr., Peoples Gas Bldg., Chicago 3.

SERVES FOR CENTURIES

Super-Hooper Scoop

To the Editor:

Your knowledge of the specific ways in which material outlined by the Association is used to advantage by members is undoubtedly a very small percentage of the actual usage. I am sending you the attached news clipping "Water Usage Charts Record Radio Program's Popularity" which starts with a quite interesting paragraph: "Although the Hooper rating boys might not buy it, The Wichita Water Company has a system that shows which radio programs are most popular."

You will, of course, recognize the seeds planted on page 20 of the October 1947 issue and page 10 of the September 1948 issue of the JOURNAL as closely related to the news article in the *Wichita Eagle*. Articles such as these two, along with the excellent series of articles in "Silent Service Is Not Enough," plant seeds which grow into many varieties of stories.

In this particular case the reporter was interested in cold statistics. Our conversation drifted into generalizations and even reminiscenses. The Amos and Andy program of fifteen to twenty years ago was mentioned, and it did not take very long for this alert reporter to have a local story with a new slant. This story was well received and I know from the number of comments which have been made that it was very widely read.

Thanks are due for the grand job the Association is doing in helping us, not only along technical lines, but also in connection with public relations and other intangibles.

ROBERT S. MILLAR

Manager, Wichita Water Co.
P. O. Box 1442
Wichita 1, Kan.; Nov. 17, 1948

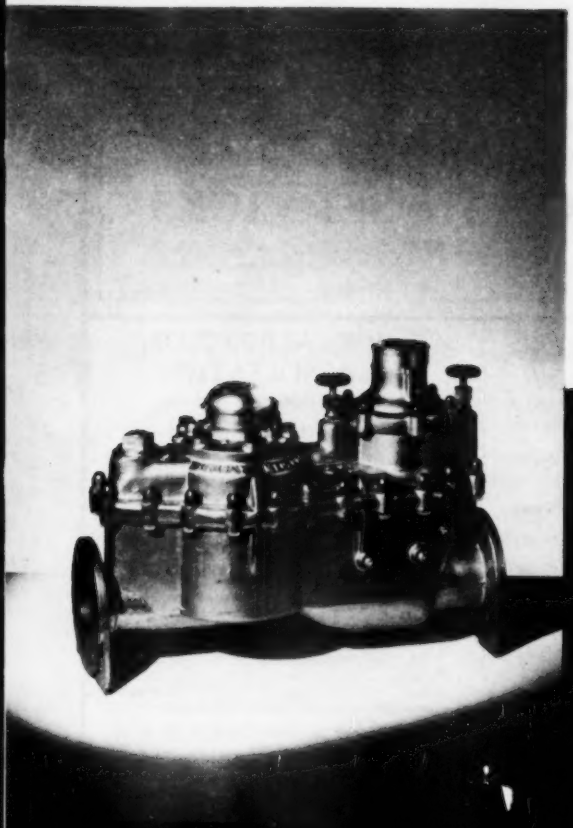
IN BULLETIN 1, THE CORRELATING COMMITTEE ON CATHODIC PROTECTION OF THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS SAYS:

The fundamentals of Cathodic Protection are simple, but solution of the inherent technical and economic problems requires a high degree of technical skill.

Electro Rust-Proofing has the technical skill and offers the services of a competent design, installation and service organization capable of handling all phases of Cathodic Protection for tanks, pipe lines and other structures in contact with water or soil.

ELECTRO RUST-PROOFING CORP., (N. J.)
BELLEVILLE 9, NEW JERSEY
REPRESENTED IN PRINCIPAL CITIES

E 8



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HERSEY COMPOUND METERS
are universally on the preferential list of experienced water works officials because back of these meters are more than 60 years of engineering and manufacturing skill, assuring real dependability, accuracy and low maintenance cost.

All Bronze Case up to 6 inches

HERSEY MANUFACTURING COMPANY
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Send for your free copy of "A List of A.W.W.A. Publications," listing books, manuals and specifications published by the Association.

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(Established 1888)

Inspection and Test at Point
of Origin of Pumps, Tanks,
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Water Works
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Membership Changes

NEW MEMBERS

Applications received December 1 to 31, 1948

Bailey, Robert T., Resident Engr., Crystal Beach, Ont., Can. (Jan. '49)

Bakes, Hiram, Resident Engr., Parsons, Brinckerhoff, Hall & Macdonald, Box 137, Kent, Ohio (Jan. '49)

Bartlett, Rollie J., Supt. of Distr., City Water Works, Box 208, 128 S. 4th St., Paducah, Ky. (Jan. '49)

Behmer, Harry L., *see* Logansport State Hospital

Bethencourt, Daniel, Civ. Engr., Public Works Dept., Vapor 165 (Altos.), Havana, Cuba (Jan. '49)

Bowman, James W., Civ. Engr., Alvord, Burdick & Howson, 20 N. Wacker Drive, Chicago 6, Ill. (Jan. '49)

Clayton, Pete, Supt., Munic. Water Dept , Avon, Ill. (Jan. '49)

Columbia City, City of, L. L. McDaniel, Supt. of Utils., City Hall, Columbia City, Ind. (Corp. M. Jan. '49)

Cowser, Kenneth E., San. Engr. I, Dist. Unit 11, State Dept. of Public Health, 402 Macon County Bldg., Decatur, Ill. (Jr. M. Jan. '49)

Creecy, Elmer, Carlos Well Supply Co., 120 Lipscombe, Mobile, Ala. (Jan. '49)

Cross Water Co., A. V. Handorf Jr., 109 W. Main St., Puente, Calif. (Corp. M. Jan. '49)

D'Amour, Francis J., Sr. Sanitarian, Houghton-Keweenaw-Baraga Health Dist., 602 Sheldon Ave., Houghton, Mich. (Jan. '49)

De Vera M., Manuel E., Prof. of Hydraulics, Univ. of Havana, Lugareno 151 esq. Mantoro, Havana, Cuba (Jan. '49)

Dohn, Charles W., Civ. Engr., 7041—67th Pl., Glendale 27, N.Y. (Jan. '49)

Dunwoody, G. A., Partner, Brink-Dunwoody-Cooper, 1½ E. Madison, Iola, Kan. (Jan. '49)

Fernandez M., Arturo M., Chief Engr., Water Works, Cia. de Acueductos de Cuba, Apdo. 25, Marianao, Havana, Cuba (Jan. '49)

Garcia Montes y Angulo, Rafael, Civ. Engr., Ministry of Public Works, Sociedad Cubana de Ingenieros, Havana, Cuba (Jan. '49)

Gomez, Rafael, Design Engr., Ministerio de Obras Publicas, Pozos Dulces 7, Havana, Cuba (Jan. '49)

Handorf, A. V., Jr., *see* Cross Water Co.

Hands, Glenn E., Prin. Engr., Burns & McDonnell Eng. Co., Box 7088, Kansas City, Mo. (Jan. '49)

Harmar, William W., Jr., Sales Repr., Welsbach Corp., 1500 Walnut St., Philadelphia 2, Pa. (Jan. '49)

Holt, Joseph F., Hydr. Engr., Public Service Com., 2240 E. Tremont Ave., New York 62, N.Y. (Jan. '49)

Jones, Paul, Cons. Engr., Jones & Donan, Madisonville, Ky. (Jan. '49)

King, H. W., Sales Engr., Johns-Manville Sales Corp., 119 Lincoln St., Portland, Mich. (Jan. '49)

Lang, Joe W., Geologist in Charge, U.S. Geological Survey, 712 City Hall, Houston 2, Tex. (Jan. '49)

Lawrenceville, Town of, Water Com., Lawrenceville, Va. (Corp. M. Jan. '49)

Lexington Water Co., Inc., Marlin F. Thomas, Vice-Pres. & Treas., 303—3rd National Bank Bldg., Nashville 3, Tenn. (Corp. M. Jan. '49)

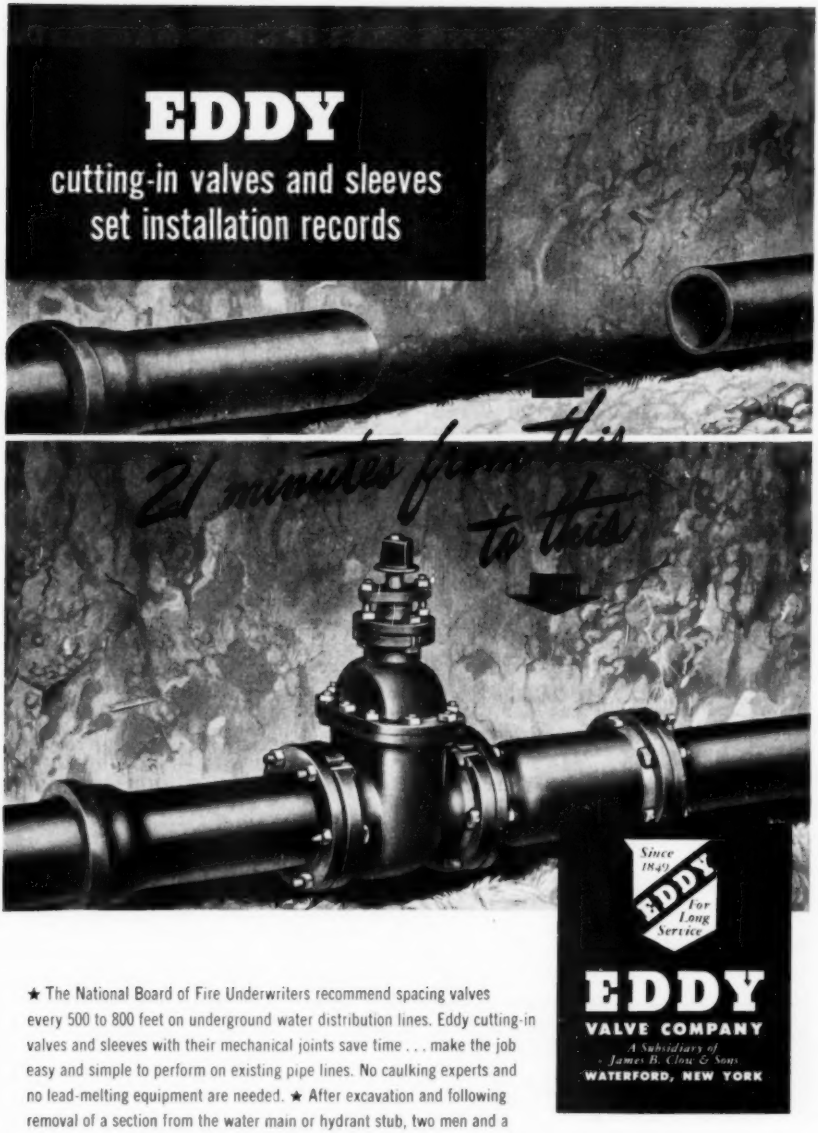
Logansport State Hospital, Harry L. Behmer, Maint. Engr., Longcliff, Logansport, Ind. (Corp. M. Jan. '49)

Mattison, R. E., Jr., *see* Suburban Water Co.

McDaniel, L. L., *see* Columbia City, City of

Missouri Power & Light Co., D. W. Snyder Jr., Pres., 106 W. High St., Jefferson City, Mo. (Corp. M. Jan. '49)

(*Continued on page 30*)



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Morales, Ricardo, Cons. Engr., Cia. de Tugenieria Morgran, Radiocentro 716, Havana, Cuba (Jan. '49)

Morey, David D., Sr. Hydr. Engr., Public Service Com., State Office Bldg., Albany, N.Y. (Jan. '49)

Murphy, C. A., *see* Murphy Equipment Co.

Murphy Equipment Co., C. A. Murphy, 322 E. Howard Ave., Decatur, Ga. (Corp. M. Jan. '49)

Paessler, Alfred H. Chem. Engr., State Water Control Board, 815 E. Franklin St., Richmond 19, Va. (Jan. '49)

Parsly, R. G., Pres., Illinois Cities Water Co., 37 Wall St., New York 5, N.Y. (Jan. '49)

Peerson, H. W., Drilling Co., H. W. Peerson Jr., 1114—7th Ave., S., Birmingham, Ala. (Assoc. M. Jan. '49)

Perrow, Warren C., Cons. Engr., 309 Sauers Office Bldg., Richmond, Va. (Jan. '49)

Pollard, James, Mgr., Commercial Dept., Pacific Gas & Elec. Co., 245 Market St., San Francisco 6, Calif. (Jan. '49)

Pollock, Joseph E., Safety Service Director, 408 S. 2nd St., Miamisburg, Ohio (Affil. Jan. '49)

Pujol, Juan B., Civ. Engr., Public Works Dept., 632 Hospital St., Havana, Cuba (Jan. '49)

Riber, E. J., Chief Engr., Water Dept., Bowling Green, Ky. (Jan. '49)

Richmond, Maurice S., Supt., Water Dept., 400 Abbott Rd., East Lansing, Mich. (Jan. '49)

Snyder, D. W., Jr., *see* Missouri Power & Light Co.

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Stapleton, Kenneth K., Partner, Casler & Stapleton, Cons. Engrs., 313½ W. State St., Jacksonville, Ill. (Jan. '49)

Steele, Lewis M., Vice-Pres., W. L. Hailey & Co., 314—42nd Ave., N., Nashville, Tenn. (Jan. '49)

Surban Water Co., R. E. Mattison Jr., Pres., Box 458, Britton, Okla. (Corp. M. Jan. '49)

Swartz, Charles R., Supt. of Maint., Marine Studios, Inc., Marineland, Fla. (Jan. '49)

Thomas, Marlin F., *see* Lexington Water Co., Inc.

Thomas, Walter L., Supt., Water Works System, Mt. Vernon, Ind. (Jan. '49)

Van Der Lely, J., Secondary Recovery Engr., Shell Oil Co., Mayo Bldg., Tulsa, Okla. (Jan. '49)

Van Sleen, Robert, Supt. of Utilities, Shelby, N.C. (Jan. '49)

Veggeberg, J. M., Engr., Pumping Station Efficiency, 811 N. Michigan Ave., Chicago 11, Ill. (Jan. '49)

Weeks, James L., Asst. Mech. Engr., Operating Div., Bureau of Eng., 7614 Saginaw Ave., Chicago, Ill. (Jan. '49)

Wyatt, W. W., Supt., Water Dist. 54, Kings County, Des Moines, Wash. (Jan. '49)

Zanetti, Francisco E., Chemist-Bacteriologist, Cia. de Acueductos de Cuba, Box 1742, Havana, Cuba (Jan. '49)

REINSTATEMENT

Waldo, Cornelius T., Deputy City Engr., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '44)

LOSSES

Deaths

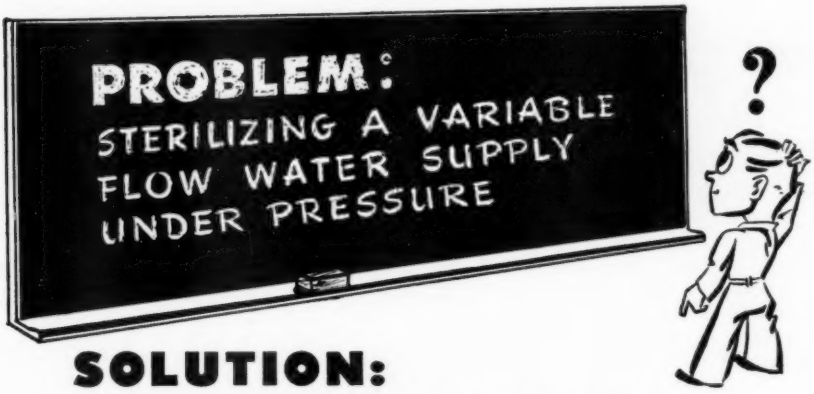
Abbott, G. H., Treas., Southbridge Water Supply Co., Southbridge, Mass. (May '12) *M*

Beckett, R. C., State San. Engr., State Board of Health, Dover, Del. (Sept. '24) *PR*

Earhart, Fred A., Comr. of Public Utilities, City Hall, New Orleans 12, La. (July '37) *MP*

Ginter, Roll, Supt., Water Works, 130 W 6th St., Newton, Kan. (Apr. '46)

(*Continued on page 32*)



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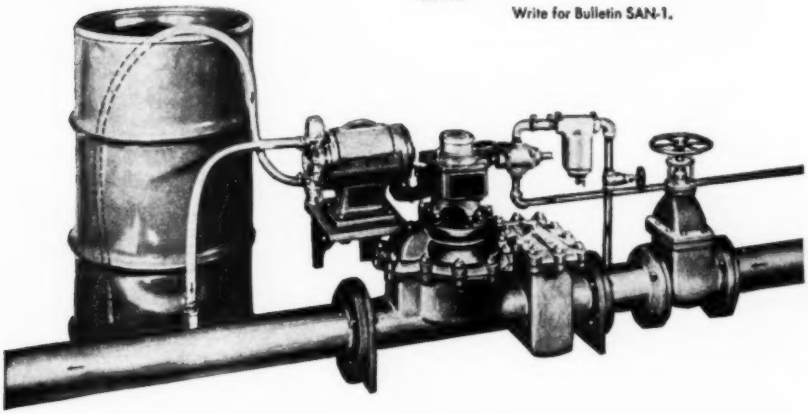

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(*Continued from page 30*)

Goudey, Ray F., 301½ S. Brand Blvd., Glendale 4, Calif. (Apr. '18) *Fuller Award '40. Goodell Prize '42. Director '45–'48. P*

Greenwood, Paul, Chief Engr., Water Works, Moorestown, N.J. (Oct. '38)

Jones, Frederick S., Special Repr., A. D. Cook, Inc., 35 Broadview Ave., Maplewood, N.J. (Jan. '45)

Matte, Hubert P. T., Cons. Engr., Worthington-Gamon Meter Co., 296 South St., Newark 5, N.J. (July '13) *MP*

Springer, H. E., Supt., Water & Light Dept., Box 215, Chisholm, Minn. (Oct. '45)

Vest, W. E., Water Dept. Consultant, City Hall, Charlotte 2, N.C. (May '11) *Director '30–'31. Honorary M. '42. M*

Walker, Edward L., 75 Vreeland Ave., Rutherford, N.J. (Jan. '34)

Woolley, Ralf R., Dist. Engr.-Water Utilization, U.S. Geological Survey, 303 Federal Bldg., Salt Lake City, Utah (July '47) *R*

CHANGES IN ADDRESS

Changes received between December 5, 1948 and January 5, 1949

Alcorn, James Dunn, Physicist, Hydraulic Div., A. O. Smith Corp., 845 El Rentro St., South Pasadena, Calif. (Jan. '47) *M*

Ambler, Edward B., Sales Repr., Builders Providence, Inc., Box 591, Denver 1, Colo. (Oct. '48)

Bandy, W. A., Route 4, Box 539, Austin, Tex. (July '44) *MP*

Berry, Garman H., City Chemist, Water Dept., Salisbury, N.C. (July '43) *MP*

Bickel, W. E., Mgr., Empire Pump & Process Co., Box 168, Riverton, Wyo. (July '46)

Blaik, D. L., Pres. & Gen. Mgr., Leak Detector Co., 330 Bulkley Bldg., Cleveland 15, Ohio (Apr. '39)

Boes, Robert J., McLean County Health Dept., 1009 N. Park St., Bloomington, Ill. (Oct. '42) *P*

(*Continued on page 34*)

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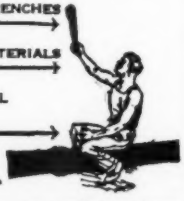

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(*Continued from page 32*)

Brady, E. J., Maint. Supt., Div. of Water, 271 Vermont St., Buffalo 13, N.Y. (Oct. '47)

Broach, Homer H., Headquarters 8th Army Engr., Sec. L-3, c/o Postmaster, San Francisco, Calif. (Apr. '46) *MP*

Bryant, Edward K., Knappen, Tippetts, Abbett Eng. Co., 62 W. 47th St., New York 19, N.Y. (Jan. '47) *MPR*

Bull, Clayton C., Cons. San. Engr., Burgess & Niple, 584 E. Broad St., Columbus 15, Ohio (July '44) *P*

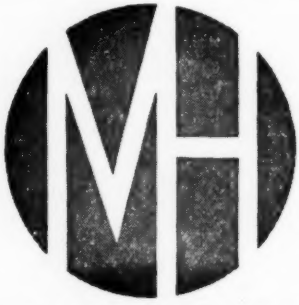
Burgess, John A., Kennedy Valve Mfg. Co., 1306–12 S. Canal, Chicago 7, Ill. (Oct. '48)

Burnham, Lyle M., Sales Engr., 2645 Portland Rd., Salem, Ore. (Oct. '40)

Canariis, Svend A., Mirasol Hotel, Tampa, Fla. (July '37)

Cates, Walter H., Contracting Engr., Consolidated Western Steel Corp., Box 2015 Terminal Annex, Los Angeles 54, Calif. (Sept. '31)

Chamberlain, L. H., Pres., Builders-Pacific, Inc., Drawer 1, Station A, Berkeley 2, Calif. (Jan. '24) *P*



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Cole, Thomas A., Bacteriologist & Supt. of Filtration, 26 Fountain Pl., Poughkeepsie, N.Y. (Jan. '35) *MPR*

Collins, W. L., Dallas Southwest Co., 3111 Culver St., Dallas 10, Tex. (Jan. '47)

Cory, J. C., Cory Eng. Co., Box 637, Miles City, Mont. (Jan. '44) *P*

Craig, Charles P., Water Supervisor, Reigel Paper Corp., Milford, N.J. (Jan. '42) *MP*

Culter, L. W., 5002 Webster Ave., West Palm Beach, Fla. (Apr. '34) *P*

Eckart, Nelson A., Cons. Engr., 242—30th Ave., San Francisco 21, Calif. (Mar. '30) *Director '36–'39. M*

Egan, James F., 2560 Cypress Way, Cincinnati 12, Ohio (Jan. '46) *M*

Foerster, William K., Gen. Mgr., San Gabriel County Water Dist., 106 N. San Gabriel Blvd., San Gabriel, Calif. (July '39)

Gifford-Hill American, Inc., Ray A. Foley, Pres., Box 1058, Grand Prairie, Tex. (Assoc. M. Apr. '45)

Gouin, Paul, Supt., Filtration Plant, 28 B. St. Sylvestre St., Longueuil, Que. (Apr. '41) *P*

Hall, John D., 518 N. Wilbur Ave., Sayre, Pa. (Oct. '37) *MP*

Hanson, Arthur M., U.S. Public Health Service, Box 474, Niagara Falls, N.Y. (Oct. '43) *P*

Harrington, John H., 1180 Drummond St., Montreal, Que. (Jan. '37) *P*

Heyward, Nathaniel J., 3115 White Ave., Baltimore 14, Md. (July '45) *P*

Hill, Wesley R., Dist. Mgr., California Water Service Co., Box 67, Concord, Calif. (July '46)

Horn, Theodore C., Supt., South Huntington Water Dist., 26 E. 24th St., Huntington Station, N.Y. (Oct. '46)

Humber, Joseph B., 4016 Huey St., Houston 12, Tex. (Apr. '47) *P*

Kazmann, Raphael G., Hydrologic Engr., Ranney Method Water Supplies, Inc., Box 277, Bexley Station, Columbus 9, Ohio (Apr. '46) *R*

Keyak, Michael H., Water Dept., 425 Mason St., San Francisco, Calif. (Oct. '41) *P*

(*Continued on page 36*)

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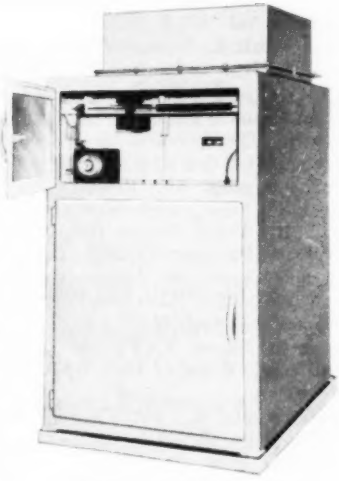

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OMEGA

(*Continued from page 34*)

Larkin, William H., 175 Main St., White Plains, N.Y. (Apr. '30) *PR*

Lee, Lester, Hitchcock & Estabrook, 521 Sexton Bldg., Minneapolis, Minn. (Apr. '44) *M*

Lesslie, John N., Jr., Supt. of Operations, Water & Sewage Dept., 103 Mitchell Ave., Salisbury, N.C. (Jan. '39)

Martin, Frank A., Dist. Mgr., Wallace & Tiernan Co., Inc., 4225 Hampton Ave., St. Louis 9, Mo. (Apr. '44) *P*

Mason, William Caton, Hydr. Equipment, 4423 N. Paulina St., Chicago 40, Ill. (July '42) *P*

McClintock, John Harper, 1017 Sunset Drive, Baytown B, Tex. (Oct. '46)

McCulley, E. B., Supervisor of Utilities, Pharr, Tex. (Jan. '46) *MP*

McGrath, R. L., U.S. Public Health Service, Swan Island Bldg. 24, Portland 18, Ore. (Apr. '43) *R*

McGuire, Orla E., Bureau of Labs., State Dept. of Health, Lansing, Mich. (Jan. '39) *P*

Melcher, Frank W., Chemist, Quality Control Div., The Coca-Cola Co., 310 North Ave., N.W., Atlanta 1, Ga. (Oct. '43) *P*

Merrill, Reynold C., Research Mgr., Chemical Dept., Philadelphia Quartz Co., 1133 Public Ledger Bldg., Philadelphia 6, Pa. (Jan. '47) *P*

Merryfield, Fred, 204 Industrial Bldg., 17th & May Sts., Corvallis, Ore. (May '34) *Fuller Award '44. P*

Narayanan Nayar, V. P., 363 Central Y.M.C.A., Toronto, Ont. (Jan. '48) *MPR*

Nichols, James R., 664 Crescent, San Bernardino, Calif. (Apr. '48)

O'Neill, Ralph W., Cons. Engr., 302½ S. Brand St., Glendale 4, Calif. (Jan. '44) *PR*

Pierce, D. O., Box 109, Kankakee, Ill. (Oct. '45) *MR*

Plummer, Raymond B., Francis Eng. Co., Cutler Bldg., Rockford, Ill. (Oct. '43) *P*

Pomeroy, Richard, Cons. Chem. Engr., 660 S. Fair Oaks Ave., Pasadena 2, Calif. (Oct. '43) *P*

Potter, James T., 1521 Stanford Pl., Charlotte, N.C. (Jan. '39) *P*

Rice, William J., 1024 S. El Molina St., Alhambra, Calif. (Oct. '44)

Riley, Harley M., Dist. San. Engr., State Dept. of Health, 190 Adams St., Delmar, N.Y. (Apr. '46) *P*

Rubbo, Jacob F., Supt. of Filtration, City Water Works, 524—7th St., Iron Mountain, Mich. (July '38) *MP*

Ruble, R. O., Cons. Engr., 223 Montezuma St., Santa Fe, N.M. (Oct. '46)

Ruston, G. H., Asst. Mgr., Water Dept., 20 Salem Ave., S.E., Roanoke, Va. (Apr. '40) *M*

Schirk, John M., San. Engr., 804 E. 3rd St., Casper, Wyo. (Oct. '48)

Schwarz, George M., Armco Drainage & Metal Products, Inc., 2321 S.E. Gladstone St., Portland 2, Ore. (Jan. '47)

Senges, D. C., 31 New Ardmore Ave., Brookthorpe Hills, Newton Square, Pa. (Jan. '39) *P*

Shull, Albert B., 5941 Calhoun Ave., Van Nuys, Calif. (Apr. '33) *P*

Silberbauer, Walter R., Supt., Campbell Water Co., 70 W. Campbell Ave., Campbell, Calif. (Oct. '43) *M*

Sitler, W. S., San Engr., 6005 N. 18th St., Arlington, Va. (Jan. '46)

Smith, Chester A., 1636 Opechee Way, Glendale 8, Calif. (Sept. '24) *P*

Stolp, Amer C., Dist. Mgr., California Water Service Co., Route 1, Box 63, Durham, Calif. (Nov. '33)

Straub, Conrad P., Goshen Apt. No. 9, Oak Ridge, Tenn. (Jan. '40) *PR*

Tate, R. H., Supt., Water & Sewer Dept., Box U, Post, Tex. (Apr. '43)

Technical Assn. Pulp & Paper Industry, Lewis B. Miller, 3753 Wilson Ave., Cincinnati 20, Ohio (Corp. M. Apr. '41) *PR*

Thompson, A. C., Water & Sewage Supt., City of Jacinto City, 10433 Market St. Rd., Houston 15, Tex. (Oct. '48)

Thompson, Albert T., Jr., 1600 Hartford Rd., Austin, Tex. (July '48)

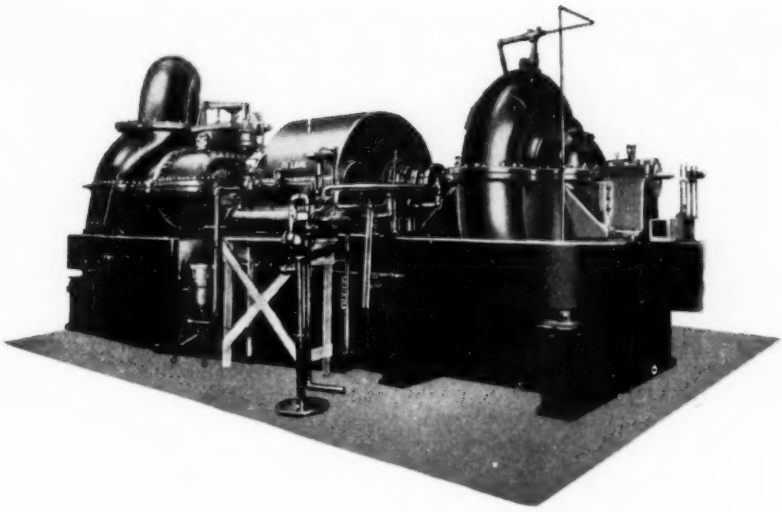
Velzy, Charles R., Nussbaumer, Clarke & Velzy, 52 Vanderbilt Ave., New York 17, N.Y. (Apr. '37) *P*

Wagner, Karl B., Public Utility Contractor, Box 4116, Austin, Tex. (July '46)

Wannoni, Luis, Avenida San Felipe No. 32, Urbanizacion la Castellana, Caracas, Venezuela (Jan. '47) *M*

Weiner, Daniel J., 146 E. Delason, Youngstown 5, Ohio (July '46) *MPR*

Weiss, Fred, Foreman, Dept. of Water & Power, Box 152, Van Nuys, Calif. (July '44)



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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C. A.—Chemical Abstracts; I. M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (Great Britain).*

BACTERIOLOGY

Bacteriology of Water Samples From Water Mains. E. W. TAYLOR. Proc. Soc. Applied Bact. (Gt. Br.), p.34 ('47). Water derived from rivers and lakes may deteriorate in extremities of distr. system. Normally, however, one does not expect to find microbial multiplication in this part of system under conditions of modern controlled and treated supplies. Nevertheless, water in pipes of large premises, such as blocks of offices and flats, liable to become stagnant and warmed by proximity to hot water and heating pipes. This encourages fungus growths, which give a moldy odor to water. More important source of contamn. within distr. system arises from manipulation of new and repaired mains; and examn. of water therefrom after chlorination important aspect of mains bacteriology. This became of particular importance during war, when bomb damage caused to mains, sewers and drains lying adjacent in roadways. Now established practice of Metropolitan Water Board in London to sample all repaired and disinfected mains and to insure that water conforms to accepted stds. before mains returned to service. Efficient disinfection of repaired mains notoriously difficult to achieve. Author considers 3 possible sources from which infection may arise at site of repair: [1] silt in main, [2] infection from trench, [3] contamn. of jute yarn used in making joints. First not likely source of infection; on other hand, every sample of mud and water from trench examnd. in course of investigation contained coliform bacteria, with *Esch. coli* Type I predominating. Similar results obtained from samples of jute yarn from each repair, which contained abundant coliform organisms of every type; for example, 1 g. of raw yarn yielded over 1,000,000 bacteria on agar at 37°C. and coliform count of over 100. Emphasized, however, that *Esch. coli* Type I never isolated from yarn obtained direct from store, which suggests that the fecal organisms probably derived from handling or exposure of yarn. Raw yarn also yielded fecal streptococci. Operation of retting Indian plant from which jute yarn derived often carried out crudely, so that coliform contamn. may readily occur. Cellobiose one of byproducts of breakdown process and well known that *Aer. aerogenes* and Irregular Type VI strains usually ferment cellobiose; latter organism has been isolated so frequently from yarn that it is called "yarn organism"; its chief difference from *Aer. aerogenes* is its ability to ferment lactose at 44°C. However, since *Esch. coli* can also survive on retted fibers in symbiosis with other organisms, it must be inferred that pathogenic intestinal organisms can do likewise; and therefore introduction of fecal contamn. into main during repair may result in persistence of potentially dangerous bacteria in yarn: in fact, shown experimentally in author's labs. that enteric bacilli

(*Continued on page 40*)

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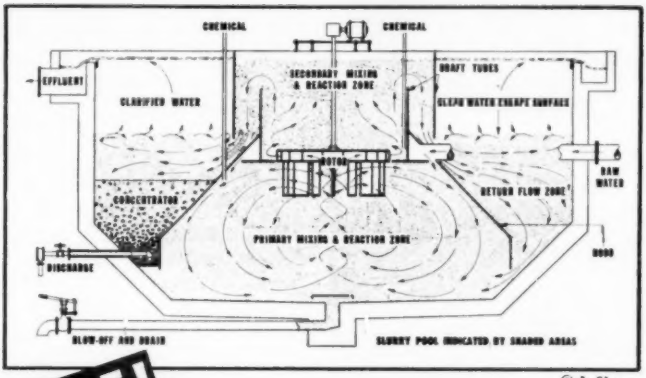

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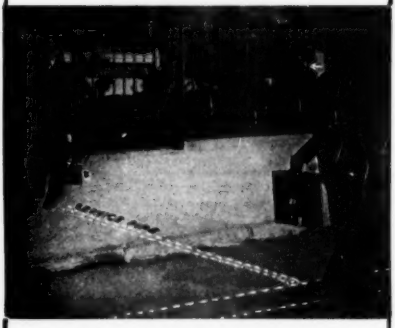

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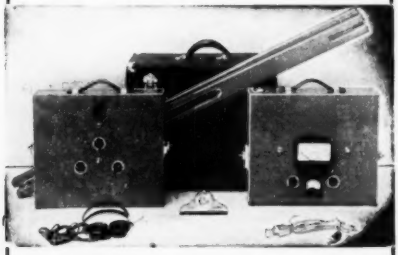

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(*Continued from page 38*)

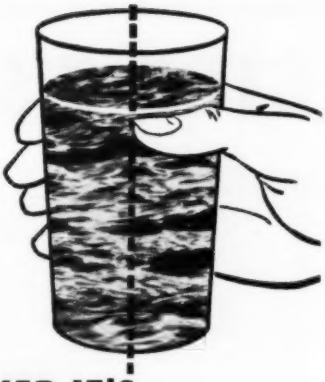
multiply several thousandfold on this material. Tables based on results of anals. of water from mains between '41 and '46 indicated seasonal occurrence of coliform organisms: when water temp. rises above 10°C. *Aer. aerogenes* prevails; Irregular VI more frequent above 13°C.; and *Esch. coli* increases between 13° and 17°C. In lab. expt., yarn in tap water examnd. for coliform counts and identification at 4°, 10°, 16° and 22°C. Results shown in table indicate immediate increase in coliform count at 22°C. and 16°C. persisting for 6 wk. and with "yarn organisms" very much in evidence. At 10°C. rise in count delayed for 5 days and *Aerogenes* predominated; yarn organisms appeared only between 9th and 14th days; at 4°C. no multiplication of these organisms. *Esch. coli* Type I not isolated at any temp. These findings agree with seasonal results found in samples from mains and show that coliform bacteria from yarn in joints thrive at certain times of year. Nature of yarn and complicated layout of mains render effective chlorination difficult; *Aerogenes*-infected section particularly difficult to deal with successfully and it may take several weeks to eradicate organisms. Evident that coliform organisms and intestinal pathogens multiplying in yarn which is constantly in contact with water in mains not only extremely difficult to deal with, since ordinary chloramine residuals would have no disinfectant action, but their presence also makes bacteriological opinion difficult. Researches being made into better means of disinfecting mains and sterilizing joint packing. [Increase of coliform bacteria in water at higher temps. particularly important in tropics, where water supplies so often primitive and sources of poln. widespread: present reviewer has experienced in East Africa many examples of coliform contamn. of

distr. systems by poln. from such sources as birds, lizards and bats. Jute and similar packings provide eminently suitable conditions for support of coliform growth in tropics, and these organisms in fact isolated from such source in water pumps by Schöbl and Ramirez in Manila as long ago as '25.]—*B.H.*

Quantitative Study of Bacteriophage of the Sea. A. GUELIN. Ann. Inst. Pasteur (Fr.), **74**:2:102 (Feb. '48). Samples of sea water taken at various points in and around port of Roscoff (Brest Peninsula) tested for their content of phage active against *Esch. coli* (Strain 36, Burnet). Phage not found off shore, but frequently present within 10–20 m. of coast and found in greatest quant. close to habitations or bathing beaches. It disappeared with rising of tide and reappeared as tide receded. Samples rich in phage to *Esch. coli* often also contained phages active against typhoid, paratyphoid and dysentery bacilli, particularly if specimen taken from muddy places in which organisms might survive and phage might multiply. Bacteriophages survive longer than bacteria in sea water. Author concludes presence of phage is good measure of degree of intestinal poln. of sea water.—*B.H.*

Enumeration, Isolation and Study of Fecal Streptococci From River Water. C. L. HANNAY & IRENE L. NORTON. Proc. Soc. Applied Bact. (Gt. Br.), p. 39 ('47). Study reported is bacteriological survey of River Avon in Warwickshire during '45–'46. Modification of medium of Hajna and Perry employed in examn. of water for streptococci. Observed that this medium gave underestimation of number of viable streptococci present. Comparison made between character-

(*Continued on page 42*)



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(*Continued from page 41*)

istics of these organisms with those isolated by Dible from feces. None were isolated with characteristics of either *Streptococcus lactis* or of *S. bovis*. Medium does not appear to be specific for organisms exhibiting cultural characteristics of group D (Lancefield). Claims of specificity will rest on serological grouping. Data presented indicate glucose azide broth incubated at 45° is specific for *S. faecalis* as illustrated by Mallman and Hajna and Perry. Study included test on 102 organisms. Methods described in detail.—*C.A.*

The Membrane Filter Zsigmondy for Investigation of Coliform and Salmonella Organisms in Drinking Water and Surface Water (M.F.-Method). A Contribution to the Campaign Against Enteric Fever. H. GROSSMANN & ADELAIDE BELING. Klin. Wo-chschr. (Ger.), **24–5**:43–4: 691 (Aug. '47). Zsigmondy's method consists in passing quants. of water under investigation through membrane filter from which cultures then made on solid and in fluid enrichment media. Authors describe satisfactory results obtained by this method, with use of modified Endo medium for detection of *Esch. coli* and Wilson and Blair's medium for pathogenic bacteria. Method found to be simple, rapid and economical.—*B.H.*

Iron Bacteria. M. LUCAS. Tech. l'Eau (Belg.), **2**:17 (Oct. '48). For control of oxidizing bacteria, particularly sulfur oxidizers (*Beggiatoa*, *Thiotrix*, *Thiobacilli*) sterilization by chlorination, aeration (for *Beggiatoa*), deacidification with lime and application of bituminous paint effective. To control reducing bacteria (*Sporovibrio desulfuricans*, methane bacteria) sterilization and bituminous lining recommended.—*W. Rudolfs.*

(*Continued on page 44*)

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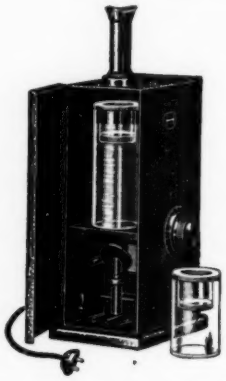

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(Continued from page 42)

HEALTH AND HYGIENE

Incoming Tide of Poliomyelitis. KNUD STOWMAN. Epidemiological and Vital Statistics Report. **1**:114 ('47). Summarized in Chronicle of the World Health Organization, **II**:2: 25 (Feb. '48). Mutation of relatively rare Heine-Medin disease into epidemic poliomyelitis of worldwide extension undoubtedly, next to '18–'19 influenza pandemic, most ominous of unsolved mysteries which last half-century has posed to epidemiologists. Important discoveries have been made in recent years in connection with poliomyelitis virus, but in some ways have served only to deepen mystery. While virus has been readily demonstrated in stools, worst epidemics have occurred in countries where sanitation at high level, and model dists. seem as exposed as poorer neighborhoods. Improvement of water supplies in North America, and northern and western Europe reflected by spectacular fall of typhoid fever incidence over last 50 yr. It is precisely in these countries that tide of poliomyelitis cases has been rising most steadily. It need hardly be pointed out that sewage disposal also has been greatly improved in these countries. Existing evidence therefore against considering poliomyelitis waterborne disease in sense in which this term commonly employed. Notification of poliomyelitis cases has improved since time of first epidemics, especially during '20's, but rise of recorded morbidity in recent years can certainly not be attributed to that cause. Any casual observer of mature age will have noticed many times more polio-crippled persons now than 40 yr. ago. Testimony of old medical journals also proves that Heine-Medin disease nowhere highly epidemic up to beginning of 20th century. Then came Scandinavian outbreaks around '05 followed by '11–'12 epidemics which

(Continued on page 46)

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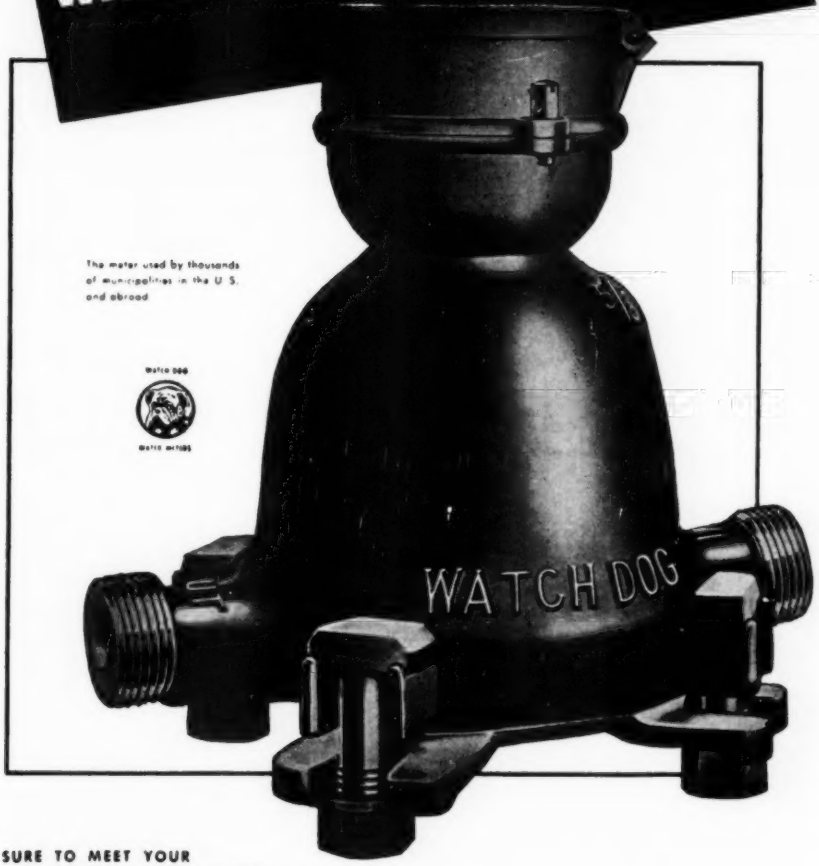

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(*Continued from page 44*)

caused nearly 8,000 cases in Sweden. In U. S., outbreaks in '12 followed by epidemic of '16, which has so far been most severe on record. After these spectacular manifestations disease settled down to slow but steady geographical extension. Outbreaks came in waves with irregular number of quieter years in between. For over 30 yr. endemic level grew gradually higher, and wave crests, too, became higher. Although '16 epidemic in U.S. not yet exceeded in any single year, total number of cases reported there during last 5 yr. about 80,000, far in excess of anything hitherto recorded for such period. Evolution has been similar in Europe, and United Kingdom has just passed through epidemic 5 times greater than any former poliomyelitis outbreak in that country. Highly significant differences in incidence of poliomyelitis exist in various zones of world, but disease actually recorded in every country endowed with proper notification system. Fig. 1 gives some indication of general trend of poliomyelitis in Europe and North America from '24 to date. European index composed of data for 7 countries—United Kingdom (not including Northern Ireland), France, Italy, Sweden (representing Scandinavia), Netherlands, Switzerland and Austria (representing central Europe). Germany not included because data for last 3 yr. incomplete or in places altogether missing. Italian data for '43 estd. Total population of 7 European countries about 160,000,000; that of United States 141,000,000. Notification of cases, on other hand, may be more complete in U. S. than in France and Italy. Two curves in Fig. 1, author finds, show no steady concurrence apart from their general upward trend, which has been most pronounced in recent years. In Europe, seems to have been sudden rise in epidemicity in '36, while similar evolution took place in U.S. 4 yr. later. American epidemics of '31 and

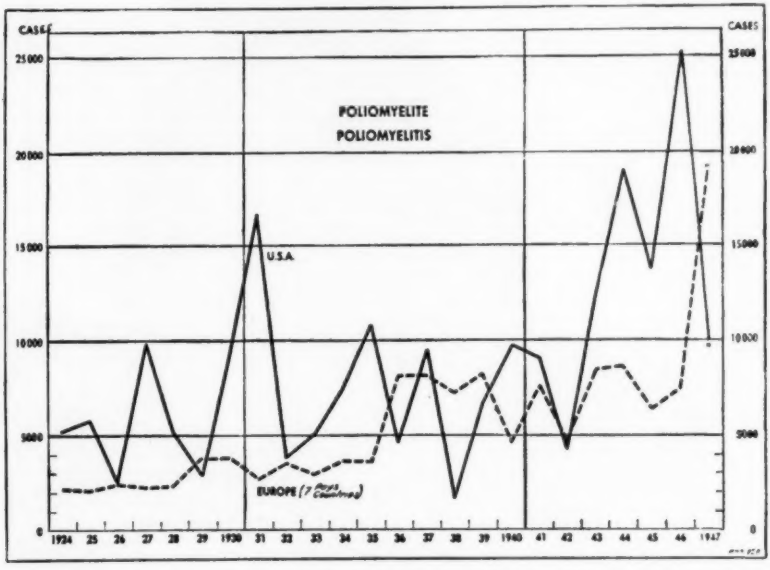

FIG. 1. Trend of Polio in Europe and U.S., 1924–47

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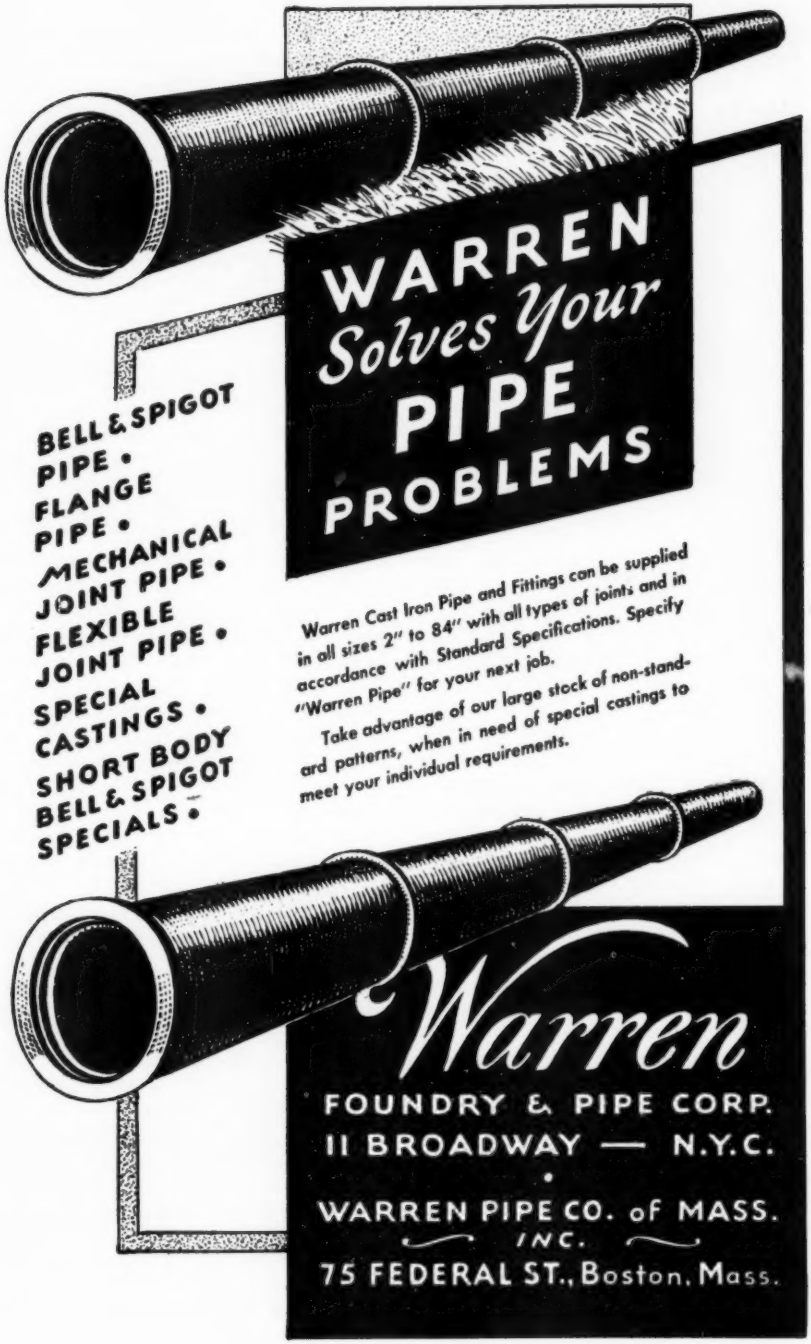
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(*Continued from page 46*)

'35 had apparently no counterpart anywhere in Europe. May or may not be significant that present record-breaking epidemics in Austria, at Berlin and in United Kingdom came just 1 yr. after great North American epidemic of '46. These general considerations on trend of disease in past substantiated by number of valuable statistical details concerning various countries.—*Ed.*

Control of Dental Caries by Artificial Fluorination of a Water Supply—Second Year. F. M. ERLENBACH & E. T. TRACY. Connecticut Health Bul., **62**:1:9 (Jan. '48). Since spring of '45, water supply at Southbury Training School, Conn., treated with sodium fluoride to provide fluorine concn. of approx. 1 ppm. Children between 5 and 16 years of age who were attending this school dentally examd. just before fluorination commenced. Children attending Mansfield State Training School also dentally examd. in order that they might constitute control group. [Fluorine content of Mansfield School water supply not recorded in this article, but presumably negligible.] Authors compare dental condition of 2 groups after 2 years' fluorination of Southbury water, limiting their data to those permanent teeth which were present in mouth at time of initial examn. They state that there were 27.8% fewer newly carious teeth among children drinking fluorine-treated water than among those drinking untreated water. On other hand, incidence of new carious surfaces on initially carious teeth was at least as great in fluorine group as in control group. [Unfortunately avg. age of fluorine group children about 1 yr. greater than that of control children, and—possibly for that reason—their initial avg. number of carious teeth was 3.7, compared with 2.8 for control group. At end of 2-year period, fluorine group children avgd. 4.6 carious teeth and control children 3.9 carious teeth. Further evidence seems to be required before one can safely conclude that fluorine added to drinking water reduces caries incidence in teeth which were erupted before addn. of fluorine.]—*B.H.*

The Inhibition of Dental Caries by Fluorine. R. WEAVER. Proc. Roy. Soc. Med. (Gt. Br.), **41**:5:284 (May '48). Existence of inverse relationship between endemic dental fluorosis and prevalence of dental caries now well known. Fluorine-free waters usually soft, but it is from deep well supplies that high fluorine figures obtained, and these waters usually hard in character. However, there should be few nowadays who believe that incidence of caries related to hardness or softness of water and there is convincing evidence from America to show that waters with caries-inhibitory properties vary widely in hardness and salt content. Appears from results of North and South Shields investigation that caries-inhibitory property of fluorine seems to be of rather short duration and seems to postpone production of maximal degree of caries for about 3–5 yr. Four methods of utilizing caries-inhibitory properties of fluorine have been suggested in order to reduce incidence of caries in areas having little or no fluorine in drinking water: [1] addn. of fluoride to drinking water; [2] administration of fluoride in solid form; [3] topical application of fluoride soln. to teeth; [4] incorporation of fluoride in dentifrices. Administration of fluoride in solid form to those to whom it will be of benefit is much to be preferred to compulsory ingestion of fluorine introduced into water at water works. Fluorine to be taken in solid form might well be incorporated in tablets of prescribed compn. contg., say, 1 mg. of fluorine as fluoride for use in area with fluorine-free water. Topical application of

(*Continued on page 50*)

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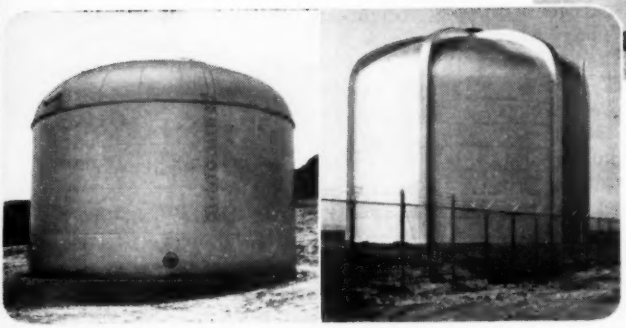

Sound, enduring performance, based on correct engineering, dependable fabrication and careful erection, assures complete satisfaction with Pittsburgh-Des Moines Steel Standpipes and Reservoirs.

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SANTA CLARA, CAL. 631 Alviso Road

(*Continued from page 48*)

fluorine by painting teeth with fluoride soln. has also been tried in America and one expt. on these lines being carried out in Britain, but judgment as to value of this method should be suspended until results of this expt. available. On other hand, Americans report striking effects which have been produced in children by multiple application of 2% sodium fluoride soln. One reason why judgment should be reserved on value of topically applied sodium fluoride is fact that results of its application to mandibular teeth have usually been less beneficial than to teeth in upper jaw. Does not appear to be any reason why fluoride should not be incorporated in dentifrices in strength, say, of 0.01% or 0.1%.—*B.H.*

Schistosomiasis: A Review of Work in Southern Rhodesia in 1946. William Alves & Dyson M. Blair. S. African Med. J. (Gt. Br.), **21**:352 (May 24, '47). Deals with progress of work started in '45 by authors and continued through '46. William Alves exptd. with administration of intravenous antimonials in schistosomiasis in treatment of 100 cases. Authors subsequently used skin test in diagnosis, utilizing antigen of schistosome cercariae. They then concerned themselves with snail destruction, using knapsack sprayers, copper sulfate, shovels, picks and hoes. Prelim. snail surveys of supposedly infested waters carried out prior to treatment with copper sulfate. Article gives amt. expended for snail destruction but does not show results obtained, if any, by methods used. Authors anticipate eventual sterilization of infested areas and organization of preventative service.—*P.H.E.A.*

The Influence of Drinking Water on the Incidence of Typhoid Fever in Nice. F. Rimattei, H. Lebout & O. Gaud. Bul. Acad. Nat. Méd. (Fr.), **131**:30–1:586 ('47). Deals with improvement in incidence of typhoid fever (including paratyphoid A and B infections) in Nice as result of introduction of several systems of water purification. From 1887 until '96, death rate from enteric disease per 1000 inhabitants varied from 31 to 46, with 72 as highest figure. Between '07 and '10, two purification plants using ozone were introduced and in period '17–'21 death rate had fallen to 20 per 1000 inhabitants. In '25, third purification plant also using ozone was built and in '29 water not purified by these three plants was chlorinated. As result, figure for '37–'41 period was reduced to 5.05. Conceded that introduction of inoculation against typhoid helped reduce incidence. Interesting to note that date given for establishment of inoculation center is '13. Anal. of causes of typhoid fever in Nice in years '12, '26, '27 and '31 shows that most cases were due either to infections contracted outside town or to cases of unknown etiology.—*B.H.*

Diseases From the Nile and Irrigation Canals. Anon. Wtr. & Wtr. Eng. (Gt. Br.) **51**:527 (Nov. '48). Four modern plagues of Egypt are bilharzia, trachoma, hookworm and pellagra, which affect 96% of pop. Nile is source of diseases infesting inhabitants. Disease-carrying worms, snails and other insects breeding in almost stagnant waters of irrigation canals find little resistance when they invade bodies of these living wretches. Sociologists est. it would take 30 to 50 yr. before any appreciable success (from health measures) could be measured in statistical tables, because 95% of pop., including upper classes, infected with trachoma; 80% bilharzia; 40% hookworm; and undetd. percentage suffering from pellagra. Underlying these grave problems are 3 factors—poverty, illiteracy and disease—which form impregnable vicious circle so far unbroken.—*H. E. Babbitt.*

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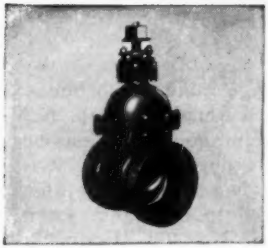
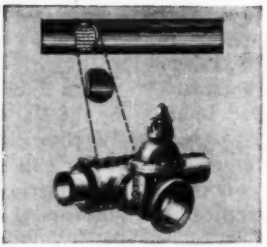
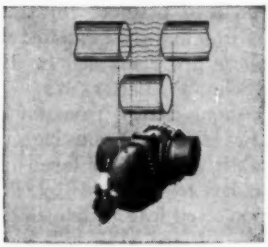
Fire Hydrants, of the compression type featuring Protectop collision protection, frost-proof tapered barrel, and positive action drain.



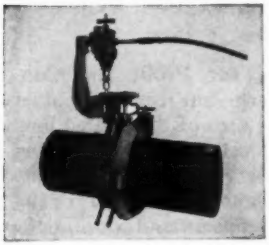
Gate Valves, for low, medium or high pressure service. Manual, hydraulic cylinder, or motor operation.



Tapping Sleeves and Valves, for making branch connections (sizes 2" thru 42") under pressure to cast iron, steel, asbestos-cement or reinforced concrete pipe of any size.

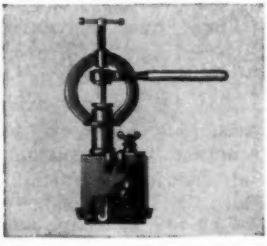


Inserting Valves, for installation under pressure in cast iron, steel or asbestos-cement pipe. Sizes 4" thru 48".



Pipe Cutting Machines. With the SMITH machine a true "lathe" cut can be made in cast iron, steel or asbestos-cement pipe in a minimum time.

Water Service Brass Goods: corporation—curb cocks, couplings and other fittings for copper tube, lead and iron pipe services.



Corporation Tapping Machines. With the SMITH Tapping Machines corporation cocks can be installed under pressure. The machine is compact and easy to operate.

*** Water works material of proven quality**

13

FIRE HYDRANTS
GATE VALVES
CHECK VALVES
INSERTING VALVES
TAPPING SLEEVES AND VALVES
WATER SERVICE BRASS GOODS

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FLOOR STANDS
INDICATOR POSTS
TAPPING MACHINES
INSERTING MACHINES
PIPE CUTTING MACHINES

Service Lines

"Power Factor and What to Do About It," publication No. 200–TEC–1077 of the Electric Machinery Mfg. Co., Minneapolis 13, Minn., offers an explanation of the essentials of power factor in industrial plants and methods of computation and, where necessary, correction.

Formulas for corrosion-inhibitive red lead primers for the protection of iron and steel exposed to the atmosphere are contained in the Red Lead Technical Letter No. 3, obtainable without charge from the Lead Industries Assn., 420 Lexington Ave., New York 17, N.Y. Eleven different formulations selected by the organization's red lead technical committee are offered, including oil and fast-drying synthetic resin vehicle paints for water storage tanks, pipelines and other uses.

Three new instrument bulletins published by the Brown Instrument Co., Wayne & Roberts Aves., Philadelphia 44, Pa., are available on request. They are entitled "Instrumentation for Treatment of Sewage and Industrial Wastes" (Bul. No. 7301), "pH and Conductivity" (Catalog 15-12) and "Pressure and Vacuum Gages" (Catalog 7000).

Dehydrated culture media and reagents for laboratory microbiology are described and their uses, specifications, history and characteristics outlined in the Eighth Edition of the Difco Manual, just published. The 1949 Difco price list has also appeared, and is available from Difco Laboratories, Inc., Detroit 1, Mich.

How metallizing can be used for maintenance and repair operations on pumps is shown in the 4-page, November 1948 issue of Metco News, available from Metallizing Engineering Co., 38–14 30th St., Long Island City 1, N.Y.

Latex-insulated building wires and cables are described and analyzed in a 20-page catalog available on request from U. S. Rubber Co., Electrical Wire & Cable Dept., Rockefeller Center, New York 20, N.Y.

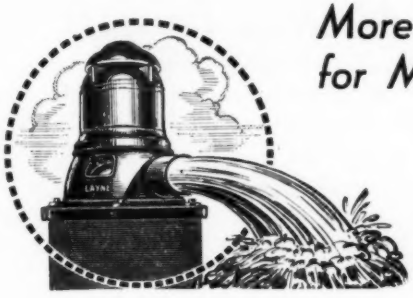
The full line of Micromax Model S indicating recorders and controllers is listed in a 32-page catalog, ND44(1) available from Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Ion exchange materials produced by the National Aluminate Corp., 6220 W. 66th Pl., Chicago 38, are described and plentifully illustrated in a series of bulletins (Nos. 40A–40G) which are constructed to fit into a special binder, Bulletin No. 40. Microphotographs of the materials, technical data, general information on the development and application of ion exchange principles and their uses, are included.

"Tunneling for Profit and Convenience" is the subject of a folder describing the uses of corrugated liner plates for constructing underpasses, culverts and service tunnels for utility lines. Distributed by Armco Drainage & Metal Products, Inc., Middletown, Ohio.

Two new chain vises for disassembling roller chains have been produced by the Baldwin-Duckworth Div. of Chain Belt Co., 369 Plainfield St., Springfield 2, Mass., and are described in Bulletin 48–4. One vise handles single-width chains from ½- to 1-in. pitch; the other is for double-width chains 1 to 2 in.

EXTRA EFFICIENCY LOWERS OPERATING COST



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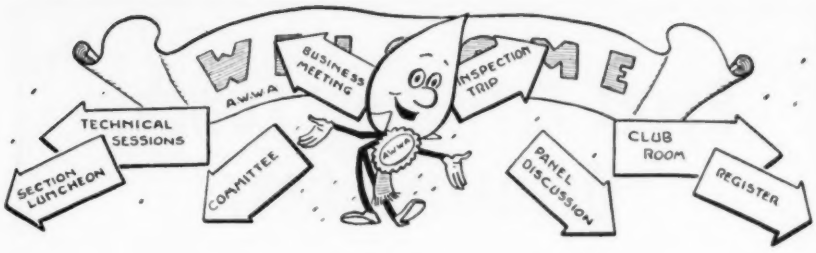

Section Meeting Reports

Arizona Section: The 1948 Fall Conference of the Arizona Sewage & Water Works Assn. was held at Hotel Westward Ho, Phoenix, on October 15–17, 1948. This marked the first anniversary of the Arizona Section, A.W.W.A., which was organized at Grand Canyon in October 1947. Total registration at the meeting was 159, an all-time high for the group. Representing the parent organizations were A.W.W.A. Vice-President A. P. Black and F.S.W.A. Past-President A. M. Rawn.

President John W. Rauscher presided over the opening session. J. P. Ward, Arizona Director of Public Health, gave the address of welcome and President Rauscher responded for the Association. The opening feature of the first technical session was a lecture by H. Gilbert Crecelius, Director of Arizona State Laboratories, on laboratory procedures in the bacteriological examination of water. The lecture was accompanied by demonstrations and slides, and a considerable interest on the part of members present was disclosed during the question-and-answer period which followed the discussion.

The new collection and disposal system in East Kingman was discussed by E. Ross Householder, Cons. Engr. The Water Pollution Control Act, adopted by the 80th Congress last June, was the topic of a discussion by Wright L. Felt, Federal Works Agency, San Francisco.

Featured speaker at the Friday luncheon was A. M. Rawn, Chief Engr. of the Los Angeles County Sanitation Dist., who discussed informally "Random Thoughts of Operational Problems of Sewerage Systems."

A feature of both the Friday and Saturday afternoon sessions was the 1½-hour Operators' Roundup, presided over by Guy A. Rhoads, Safford Utilities superintendent. The Roundup was a closed session, "for operators only," and on both days close to 100 per cent of the operators at the conference attended. The enthusiasm which marked the informal type of discussion indicates a healthy future for this feature of the program.

The Friday afternoon session, presided over jointly by President Rauscher and Vice-President A. Anton Frederickson, included a lively open

(*Continued on page 56*)

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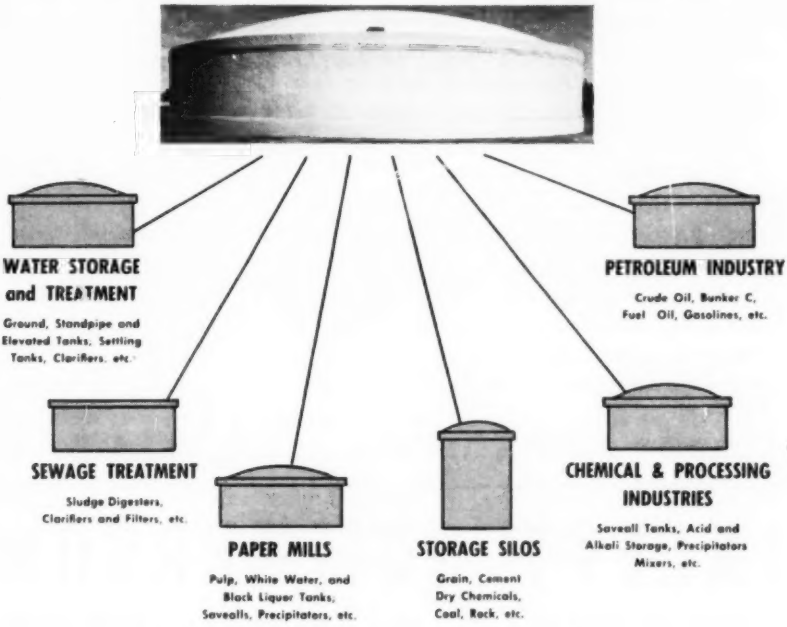
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(*Continued from page 54*)

forum on financing of water main extensions, a progress report by Harvey W. House, Pacific Coast Clay Products Inst., Los Angeles, on "Sewer Pipe Jointing," and a discussion and demonstration of pipe locators and leak detectors by Curt R. Fisher, Fisher Research Laboratory, Palo Alto, Calif.

The Friday dinner featured A.W.W.A. Vice-President Black who discussed affairs of the American Water Works Assn. Byrl D. Phelps, San Diego, acted as master of ceremonies and presided over the evening's entertainment. Dinner music was played by member John L. Mapes, R. W. Sparling Co., Los Angeles. A surprise speaker of the evening was Tom Tarbox, feature writer for the Arizona *Republic,* who presented a humorous discussion of Arizona's big problem—"Conservation of Water."

The Saturday technical session opened with a discussion by William Readey, Chief Plumbing Inspector of the City of Chicago, representing the American Society of Sanitary Engineering, on "Cross Connections and Public Health." Following this, papers were presented on "Fire Hydrant Standards" by Walter R. Staby, M. Greenberg's Sons, and "Fire Protection" by John Colton, Board of Fire Underwriters of the Pacific. Concluding the morning's session was a discussion of elevated tank maintenance by J. D. Baughman, Glendale City Manager.

(*Continued on page 58*)

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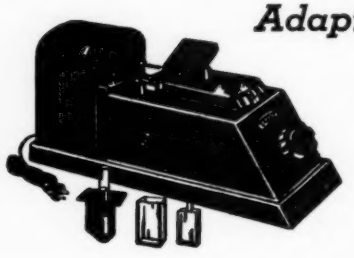

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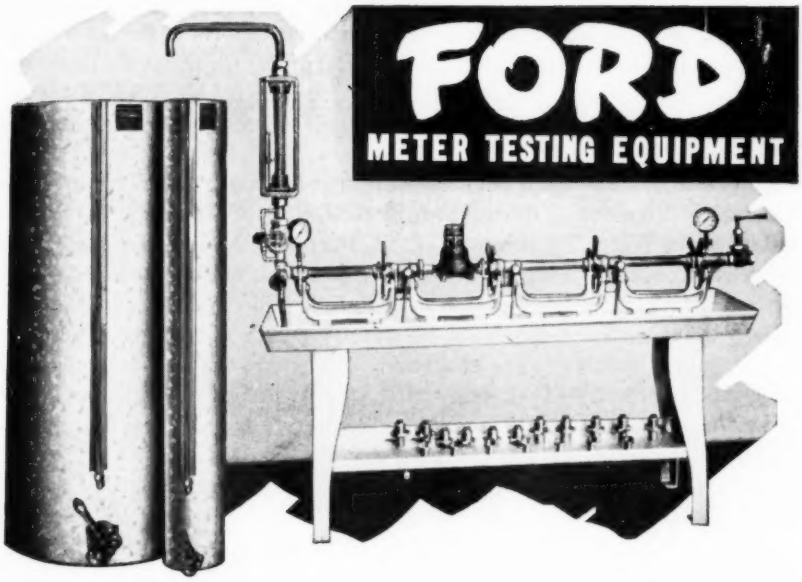

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FOR BETTER WATER SERVICES FORD

Wabash, Indiana

(*Continued from page 56*)

The Saturday luncheon was the occasion for reports of the national directors of the two parent organizations. Reporting for the A.W.W.A. was Director A. W. Miller, and for the F.S.W.A., Director Ruskin T. Gardner. Both directors reported a healthy membership increase in the Arizona Sections for 1948.

The final technical session on Saturday afternoon again featured the Operators' Roundup, followed by a discussion by A. P. Black of "Recent Advances in Water Treatment." A. B. Barrows, Byron-Jackson Co., Los Angeles, discussed "Pumps." Sam S. Headman, of the consulting engineering firm of Headman-Ferguson & Carollo, Phoenix, discussed engine-driven water works equipment and outlined methods of emergency pumping during power failures. The concluding discussion, with an accompanying film, was presented by G. J. Manahan of the A. P. Smith Mfg. Co.

The traditional Select Society of Sanitary Sludge Shovelers dinner-dance concluded the Saturday affairs. A. W. "Dusty" Miller (pH 7) was toastmaster for the evening. Musical Director Mapes led group singing and the Select Society Quartette ushered in the presentation ceremony with their "Ode to a Sludge Shoveler." The coveted certificates of membership in the honorary society were awarded to A.W.W.A. Vice-President Black and to Mrs. Florence Parker. Dancing to a late hour followed, as guests of the manufacturers represented.

A demonstration of modern fire-fighting methods and apparatus was held Sunday morning to conclude the three-day program. The demonstration, presented by the Thunderbird Sales Corp., attracted many hundreds of Phoenix residents in addition to members of the Association who were present.

Special entertainment for the ladies in attendance at the meeting was under the direction of Mrs. John Hoover and her committee, and included a Chinese luncheon and a tour of specialty shops on Friday. On Saturday, the ladies were guests for the afternoon at one of the Valley's guest ranches.

MRS. HELEN ROTTHAUS
Secretary-Treasurer

Wisconsin Section: The annual meeting of the Wisconsin Section was held at the Hotel Stoddard in LaCrosse, Wis., on October 28 and 29, 1948. The total attendance was 239.

All sessions at the Wisconsin Section meetings start with a movie. This has worked out very satisfactorily, as it insures a full attendance at the time the first speaker is to start and decreases the confusion caused by people coming in after the speaker has started talking.

This year there were four sessions: the General Session, held Thursday morning, October 28; the Surface Water Session, Thursday afternoon; the Ground Water Session, Friday morning, October 29; and the Distribu-

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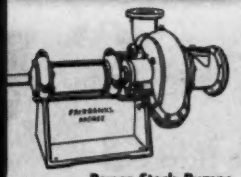
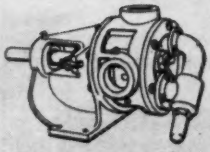
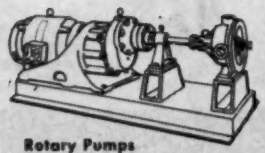


Paper Stock Pumps



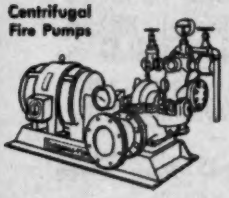
Frame Constructed Rotary Pumps

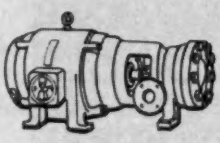


Rotary Pumps with Geared Head Motor Drive

Vertical Propeller Pumps

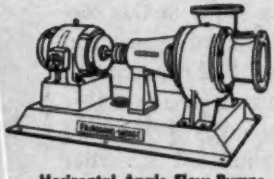
Centrifugal Fire Pumps





Two-Stage Builtogether Pumps

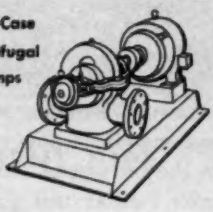
Horizontal Sewage and Trash Pumps

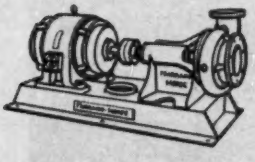


Horizontal Angle Flow Pumps

Vertical Close-Coupled Sewage and Trash Pumps

Split-Case Centrifugal Pumps

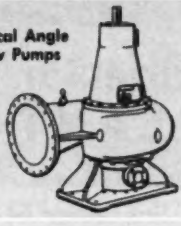




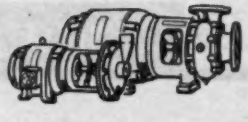
Base-Mounted Centrifugal Pumps

Vertical Sewage and Trash Pumps

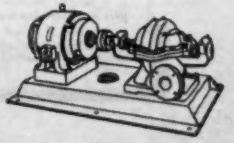
Vertical Angle Flow Pumps



Deep Well Turbine Pumps



Builtogether Centrifugal Pumps



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lasting dependability
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and STANDPIPES • FARM EQUIPMENT • MAGNETOS

(*Continued from page 58*)

tion Session, Friday afternoon. A luncheon was held at the Hotel Stoddard on Friday noon and the banquet was held Friday evening. At the luncheon, A.W.W.A. Vice-President A. P. Black spoke briefly on the objectives of the Association and the work that it was doing through the various committees. He called attention specifically to the fact that, while the membership was increasing, the losses due to resignations were greater than they should be. A local talent vaudeville provided the evening's entertainment.

Mayor Charles A. Beranek of LaCrosse welcomed the group at the beginning of the General Session and Verne A. Somers, Chairman, responded on behalf of those present. There was only one paper at this session, that of Asel Colbert of the Public Service Commission of Wisconsin, who spoke on depreciation. He called attention to the fact that depreciation rates in Wisconsin utilities are being revised at the present time and that depreciation is now computed on the basis of individual items rather than on the composite rate for depreciation used by the commission in earlier years. After this paper, a panel discussion on depreciation was led by Jerry Zufelt of Sheboygan. The others participating in the panel were Walter Peirce of Racine, A. P. Kuranz of Waukesha and H. T. Rudgal of

(*Continued on page 62*)

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1. Coagulation is effective over a much wider pH range than with other coagulants. Color flocs may be formed in the very acid range where other coagulants may not be employed. On the other hand, true hydrated ferric oxide flocs may be formed at pH 9-10 or even higher for the removal of turpidity and manganese.
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(Continued from page 60)

Milwaukee. This discussion covered the expansion program by the use of revenue bond issues, the classification of accounts and the detailed methods of handling depreciation. The general consensus of the participants was that municipal utilities were not taking great enough interest in setting up a depreciation reserve fund from current earnings so that ample funds would be available for replacement of equipment. The discussion also brought out the fact that an increase in water rates had been received by Wisconsin water utilities or was being applied for to cover the unusual increase in waterworks costs during the last two or three years. The magnitude of this increase is indicated by the fact that retired cast-iron pipe has been taken out and sold as scrap for over $50 per ton, whereas the original cost of the pipe when it was installed many years ago was only $48 per ton.

The presiding officer for the Surface Water Session was H. T. Rudgal, who took the place of J. A. Snow, who was unable to attend. The first paper, by Thomas M. Niles, of Greeley & Hansen, was on "Lake Intakes," and discussed their maintenance, including the difficulties due to ice formations. The next paper, by N. S. Chamberlin of the Wallace & Tiernan Co., was on the "Significance of Present-Day Chlorination Practices." This was a technical discussion outlining the specific reactions due to the use of chlorine under various conditions, including a discussion of superchlorination and the use of various chlorine compounds.

The panel for the afternoon's discussion, which took the form of "Information Please," was participated in by the two speakers noted above and, in addition, H. H. Gerstein of Chicago, James E. Kerslake of Milwaukee, William U. Gallaher of Appleton and Milton J. Shoemaker of the Research Products Corporation of Madison.

During the discussion of water softening, it was stated that the use of a detergent to achieve the effect of soft water throws a burden on the consumer, as it is more expensive than the use of softened water. It was concluded that water softening should pay when water exceeds 170 ppm. of hardness.

A. P. Kuranz presided at the Ground Water Session Friday morning. The first paper was by W. J. Drescher, Hydraulic Engineer, U.S.G.S., Madison, on "Quantitive Determination of Ground Water in Wisconsin." This paper gave a technical discussion of the methods used by the U.S.G.S. in determining ground water facts and the formulas which are used in interpreting the results. The next paper, by J. W. Gibb, Civ. Engr., Milwaukee County Regional Planning Dept., was entitled "Getting Water From the Ground." The panel discussion was presented by the foregoing two speakers and, in addition, E. F. Bean, State Geologist; O. J. Muegge of the State Dept. of Health; Joe Egerer, a well drilling contractor; and M. O. Nelson, representing a company which installs deep well pumping

(Continued on page 64)

WHY FAMOUS

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open easier... seal tighter!

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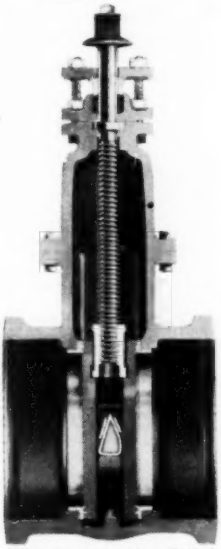

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(*Continued from page 62*)

equipment. A resolution was adopted after the discussion requesting the Legislature to provide funds for the effective use of the information by the work of the U.S.G.S.

The first paper at the Distribution Session was presented by Philip S. Davy, Cons. Engr. of LaCrosse, entitled "Water Hammer Due to Valve Closures." Frank J. Egan of James B. Clow & Sons presented a paper on "Valves in Water Distribution Systems." The panel consisted of the two speakers noted above and also Arthur Kuranz of Waukesha, Arthur Rynders of Milwaukee and H. S. Merz of Rockford.

L. A. SMITH
Secretary-Treasurer

Florida Section: For the first time in its history, the Florida Section's annual meeting was held in West Florida, November 18 to 20, 1948, at the Dixie Sherman Hotel, Panama City. There was a total of 103 present with a large number of members and guests visiting from Georgia and Alabama. Panama City gave the visitors a royal welcome with large banners across the street and Christmas lights turned on for the first time.

The addresses of welcome were given by Mayor Carl R. Gray and John M. Rainey, Manager of the Chamber of Commerce. The response was given by Chairman W. A. Glass, who gave a resume of Section activities for the past year. A.W.W.A. President Linn H. Enslow spoke on "The Association's Business is Your Business," and was followed by Vice-President A. P. Black, who spoke on "Association Affairs."

Several interesting papers were presented on water works operation and maintenance, among them "Maintenance of Electrical Equipment" by W. J. Seibert of the General Electric Co., Atlanta, Ga.; "Method of Checking Efficiency of Water Pumps" by N. C. Ebaugh, Prof. of Mech. Eng., Univ. of Florida; "Test and Maintenance of Motors" by W. T. Rimele, Meter Foreman, West Palm Beach Water Co., West Palm Beach, Fla.

(*Continued on page 66*)

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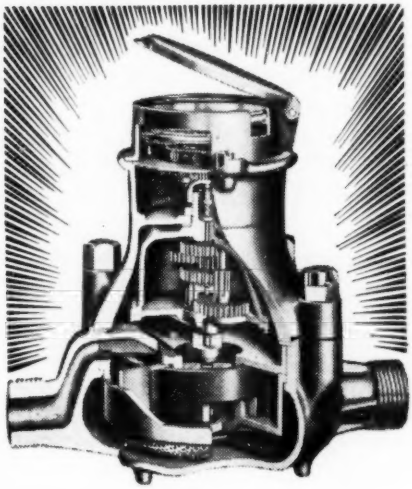

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(*Continued from page 64*)

A paper on "Improvements to Hialeah Treatment Plant" was presented by C. R. Henry, Chief Chemist (*see* p. 151, this issue).

One of the highlights of the meeting was a paper entitled "Financing Extensions and Improvements" by Ross E. Windom, City Manager, St. Petersburg, which caused considerable discussion. There was also an interesting talk on the "Functions of the Cast Iron Pipe Research Association" given by Thomas Wolfe, Engineer for that organization.

The two panel discussions were: "Deterioration of Plant and Distribution Systems" by Stanley Sweeney, Engineer of the Pensacola Water Dept., and L. L. Garrett, Supt. of Distribution, Orlando; and "Disinfection of Water Mains" by Charles H. Helwick, Supt., Jacksonville; W. H. Young, Supt., Ormond; and B. F. Borden Jr., Cons. Engr. of Jacksonville. Both of these topics provoked considerable comment and discussion.

After the opening session on Thursday, the balance of the day was devoted to entertainment features. At noon the Men's Luncheon was held at the Cove Hotel, with R. W. Fitzgerald, Supt. of the Water Dept. of Norfolk, Va., as guest speaker.

During the afternoon a tour was made of the U.S. Air Univ. at Tyndall Field. During this tour members were given a demonstration of

(*Continued on page 68*)

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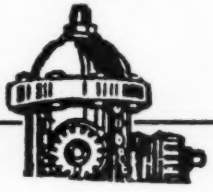

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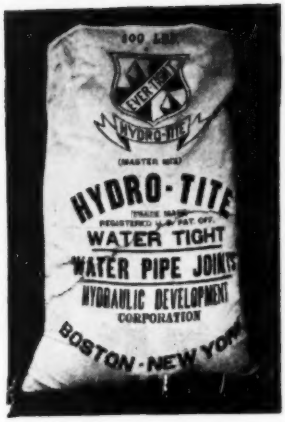

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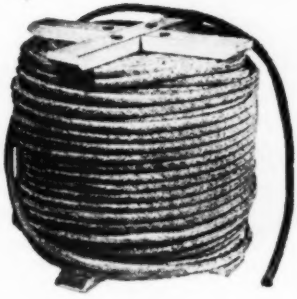

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(Continued from page 66)

actual flight training, together with aerial gunnery, sighting and range-finding.

At 6:00 P.M. the members became the guests of Panama City at the Panama Country Club, first at a cocktail party, then at a fish-fry, which was followed later with an informal dance. Entertainment was also provided for the ladies, who were included in the Thursday afternoon schedule and enjoyed a boat tour Friday morning and a tea at the Yacht Club in the afternoon.

The meeting closed with the traditional banquet at which W. B. Gibson of Atlanta presided as Master of Ceremonies, introducing the outgoing and incoming officers of the Section and also distinguished guests present.

While the attendance was somewhat smaller than usual, the meeting was an outstanding success with wholehearted welcome and cooperation from the City Commission of Panama City.

Credit for this success was given to Harry Berkstresser, Supt. of the Water Dept., Panama City, in charge of local arrangements, and to M. R. Boyce of Clearwater, Chairman for the Program Committee.

S. K. KELLER
Secretary-Treasurer

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Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Packing, Rawhide:
Mabbs Hydraulic Packing Co.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Preload Companies, The
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Dearborn Chemical Co.
Koppers Co., Inc.
Preload Companies, The
Reilly Tar & Chemical Co.
Standard Pipeprotection, Inc.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe, Steel:
Armco Drainage & Metal Products, Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Everson Mfg. Corp.
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc

Pumps, Deep Well:
American Well Works
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

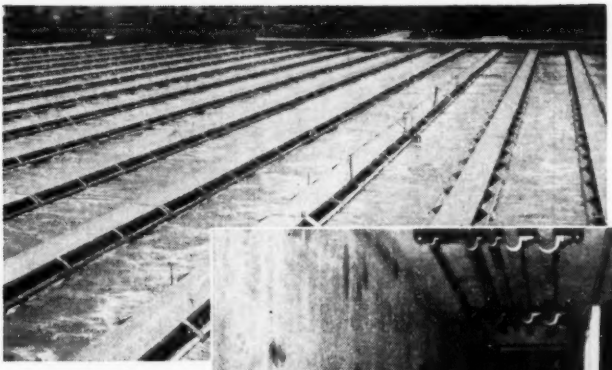
Pumps, Hydraulic Booster:
Fairbanks, Morse & Co.
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Recorders, Gas Density CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.



Everdur Electrical Conduit serves the aeration and final settling tanks in bringing power from the operating galleries to the sluice gates of the control centers, and from these centers to the operating mechanism on the center pier of each tank.

Everdur Electrical Conduit in service tunnel looking north from north gallery.

PERFORMANCE

in World's Largest Sewage Treatment Plant

. . . leads to extended use of Everdur Electrical Conduit

WHEN Chicago's Southwest Sewage Treatment Plant was built 13 years ago, it utilized 14 miles of Everdur* Electrical Conduit, in sizes from ¾" to 2½". Conduit of Everdur Metal was selected because of its high physical properties and excellent resistance to many corroding agents.

More and more Everdur Conduit went into this plant, as its 1939 capacity of 400 m.g.d. was expanded to 1,000 m.g.d. by mid-1948. Further expansion will take place over the next 5 years. Considerable Everdur Conduit is specified in several new contracts awarded to the Northern States Electric Company, Chicago.

For detailed information on Everdur Copper-Silicon Alloys in Sewage and Water Works service, write for Publications E-11 and E-5. 48188A

*Reg. U. S. Pat. Off.

ANACONDA
From mine to consumer

Everdur

COPPER-SILICON ALLOYS

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Rust Prevention:
Dearborn Chemical Co.
Electro Rust-Proofing Corp.

Sand Expansion Gages:
(See Gages)

Sand, Filtration:
(See Filtration Sand)

Sleeves:
(See Clamps)

Sleeves and Valves, Tapping:
James B. Clow & Sons
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Liquid Conditioning Corp.
Permutit Co.

Soda Ash:
Mathieson Chemical Corp.
Solvay Sales Div.

Sodium Hexametaphosphate:
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div., Inc.
Dearborn Chemical Co.
Dorr Co.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Tennessee Corp.
Zeolite Chemical Co.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Sulfur Dioxide, Liquid:
Virginia Smelting Co.

Surface Wash Equipment:
Liquid Conditioning Corp.
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Belco Industrial Equipment Div., Inc.
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Industriai Chemical Sales Div.
Infilco, Inc.
Liquid Conditioning Corp.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Vibrators (Chemical Feeding):
Syntron Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants:
(See Softeners)

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
LaMotte Chemical Products Co.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Infilco, Inc.
Liquid Conditioning Corp.
Pittsburgh-Des Moines Steel Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Acidizing:
Dowell Incorporated

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite:
Infilco, Inc.
Liquid Conditioning Corp.
Permutit Co.
Zeolite Chemical Co.

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

CENTRILINE

VARIES MORTAR-THICKNESS ACCORDING TO NEED

▶▶▶ PIPE LINING FACTS NO. 4

The Centriline process is extremely flexible in providing linings of variable thickness in accordance with the degree of protection necessary. The thickness of the lining is controlled in inverse proportion to the forward speed of the Centrifugal machine. Thus, when cleaning reveals sections of a main particularly affected by electrolysis or corrosion and strengthening is desirable, an increase in thickness is obtained by slowing the speed of the machine.

No matter what plate thickness or plate conditions are encountered—serious deterioration and penetration included—the flexibility of the Centriline Process restores capacity to better than new and vastly increases the life expectancy of the pipeline.

▶▶▶▶ WRITE TODAY FOR THE NEW CENTRILINE CATALOG

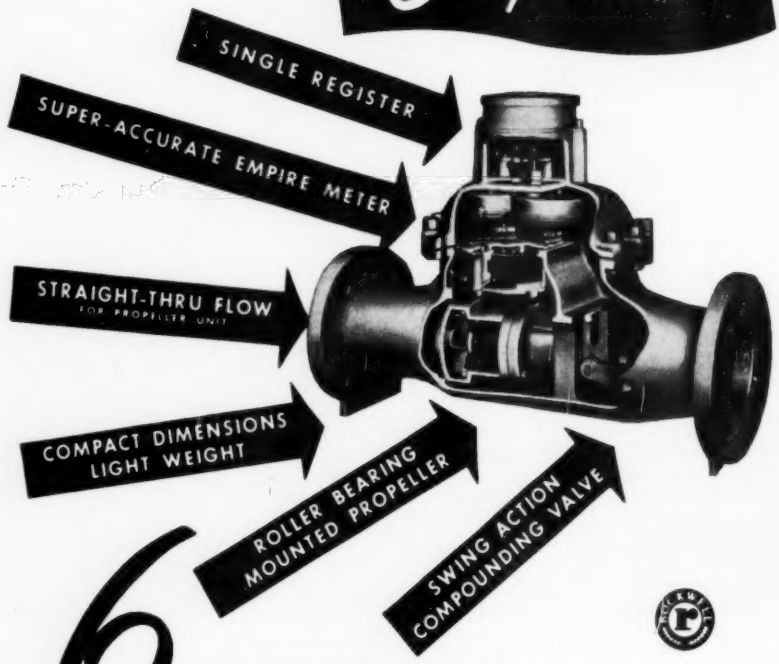
CENTRILINE CORPORATION

142 CEDAR STREET • NEW YORK 6, N. Y.

CEMENT MORTAR LININGS FOR WATER MAINS

Centrifugally Applied in Strict Conformity with A. W. W. A. Specifications

PITTSBURGH EMPIRE Compounds



6 ADVANTAGES
FOUND IN NO OTHER DESIGN

. . . and no other meter furnishes so many *conveniences* for the operating man. Consider the single register that speeds meter reading and eliminates errors. Compare the light weight of these meters against that of conventional compounds. One man can install a 3 in. Pittsburgh-Empire alone. Don't overlook maintenance ease. Full accessibility to all parts has been provided. The Pittsburgh-Empire Compound meter can be quickly dismantled or assembled while in the line. It runs smoothly, quietly, without pulsation.

Such operating conveniences, plus sound mechanical advantages add up to the greatest compound meter value ever offered. Instruction bulletin W-803 gives full facts about this superior design. Write for it!

PITTSBURGH EQUITABLE METER DIVISION
ROCKWELL MANUFACTURING CO., PITTSBURGH 8, PA.
Atlanta Boston Chicago Houston Kansas City
Los Angeles New York Pittsburgh San Francisco
Seattle Tulsa

worried about TURBID *water treatment?*

2 Step Treatment with the

DORRCO CLARIFLOCCULATOR

Can Lick Your Problem!

Turbid water . . . containing exceptionally heavy or taste-producing solids . . . poses no treatment problem for the Dorrco Clariflocculator. The two essentials of turbid water treatment . . . mechanical flocculation and continuous sedimentation . . . are carried out in a *single, compact structure.*

FLOCCULATION IN SEPARATE ZONE

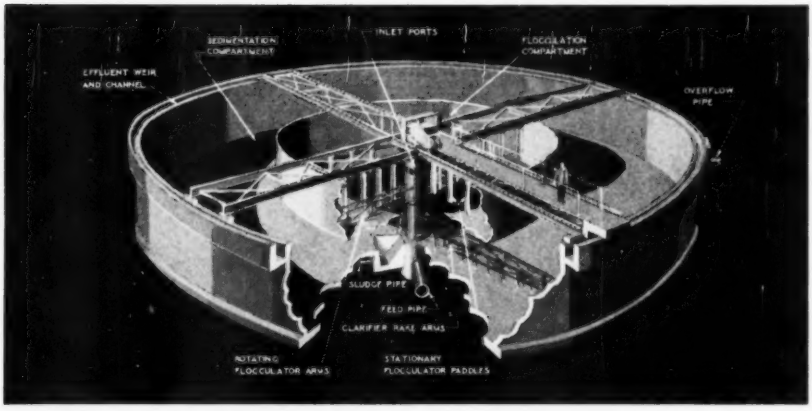
Fine, turbidity-producing solids, combined with coagulants, are made to coalesce mechanically to form flocs with rapid settling qualities.

FLOC STRUCTURE IS RETAINED

Flocs, once formed, drift gently from the flocculation zone into the sedimentation zone without disintegration.

IDEAL SEDIMENTATION CONDITIONS

Sedimentation in the annular zone results in gradually decelerated flow along radial lines to a peripheral overflow weir of maximum length.



These are the reasons why the Dorrco Clariflocculator makes *operating* sense on turbid water treatment problems. Its compact design makes sense too . . . resulting in maximum efficiency and utilization of tank area and volume with minimum space requirement.

Write for detailed information on the Dorrco Clariflocculator as applied to your specific problem. It is available in sizes ranging from 12 feet to 100 feet in diameter . . . to handle flows of from .10 to 10 MGD.

DORR

RESEARCH ENGINEERING EQUIPMENT

DORRCO

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Dorr Technical Services and Equipment Are Also Available Through Associated Companies and Representatives in the Principal Cities of the World. Names and Addresses on Request.

LEADITE

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking